

The Journal of the
**Utah Academy of
Sciences, Arts, & Letters**

Volume 96 • 2019

**Includes selected and refereed articles from the
2019 Annual Conference
held at
Weber State University
March 23, 2019**

Editor
Kristin L. Kraus

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ISBN-13: 978-0-9988268-3-7

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Cover Photo: Michael Burt, Joshua Baum, James Loveless, Phil Matheson, Raymond Perkins, “Gearing up for a Launch of a VASIMR Rocket at Utah Valley University,” p. 239.

Utah Academy of Sciences, Arts, and Letters

History: Founded 3 April 1908, the Utah Academy of Sciences was organized "to promote investigations and diffuse knowledge in all areas of science." Beginning in 1923, the Academy started publishing the papers presented in its annual meetings in *Proceedings*. In June 1933 at the annual meeting, the Academy was enlarged to include arts and letters, and the name was changed to the Utah Academy of Sciences, Arts, and Letters. Articles of incorporation and non-profit organization status were accepted by the Academy membership at the spring meeting in April 1959. In 1977, the name of the journal of the Academy was changed from *Proceedings* to *Encyclia*. It became a refereed journal at this time. In the mid 1980s, the scope of the Academy was expanded further to include (1) business, (2) education, (3) engineering, (4) library information and instruction, and (5) health, physical education, and recreation. Beginning with the 1998 issue, the journal became *The Journal of the Utah Academy of Sciences, Arts, and Letters*.

Annual Meeting: The Academy's annual meetings are normally held in the spring on one of the Utah campuses of higher education. The plenary session is called the Tanner Lecture, endowed by Mr. O.C. Tanner in 1986.

Best Paper Awards: The best paper presented in every division is given a cash award, which is presented at the Academy's "Awards Evening" held the following fall.

Distinguished Service Awards: The Academy recognizes outstanding contributions to teaching and scholarship by means of annual Distinguished Service Awards, alternating every other year between disciplines.

Membership: When the Academy was founded in 1908, membership was by nomination, ratified by the Council, and elected by a "three-fourths votes of members present." Today, the Academy's membership is available by application.

Institutional Members: All Utah institutions of higher education are members of the Utah Academy. The Academy appreciates their patronage.

Publication Policy

The *Journal of the Utah Academy of Sciences, Arts, and Letters* publishes works in all of the fields of study encompassed in the Academy's mission. Papers published in *The Journal of the Utah Academy of Sciences, Arts, and Letters* are drawn from papers presented by members in good standing at the annual conference of the Utah Academy. To qualify for publication, the papers must be recommended through a refereeing system.

Presenters are encouraged to publish their paper in *The Journal of the Utah Academy*. *The Journal's* criteria are that a submission is (1) fresh, meaningful scholarly insight on its subject; (2) readable and well written; and (3) of general interest for an academic readership beyond the author's field.

If you wish your paper to be considered for publication in *The Journal*, please submit a Microsoft Word document to the section editor of the appropriate section by the indicated deadline. Contact information for the section editors is available on the Utah Academy's website (www.utahacademy.org).

The Journal of the Utah Academy is a refereed journal. Editorial responses will be forthcoming after the resumption of school the following fall when referees have returned their comments to the division chairs.

Papers should be between 10 and 20 double-spaced pages. Detailed instructions to authors are available at http://www.utahacademy.org/Instructions_for_Authors.pdf.

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DISTINGUISHED SERVICE AWARD

The Distinguished Service Award is given to an academic professional for exceptional service to the higher education community in Utah.

Alan and Jeanne Hall

Alan and Jeanne Hall, both individually and jointly, serve their community by generously supporting access to education. After their marriage and graduation from Weber State College, the Halls joined the Peace Corps in Brazil, an experience that had a lasting influence and cemented their commitment to community involvement and service. Upon their return, they attended BYU where Jeanne earned a master's degree in psychology, and Alan completed an MBA. Jeanne is a certified school counselor and worked with at-risk students in the Ogden School District for almost 20 years. She also served as President of Boys and Girls Clubs of Weber-Davis. Alan has served in many community leadership roles, including Chair of the Weber State University Board of Trustees. Alan and Jeanne Hall established and serve as Chair and President of the Hall Foundation at Weber State. The foundation's mission is to provide educational opportunities to the less fortunate, compassionate care to the afflicted, food to the hungry, cultural experiences to the community and support to cultural and educational organizations. Their philanthropic efforts support a wide range of community organizations. Alan and Jeanne Hall exemplify the ideals of distinguished service in education as they enthusiastically support Weber State, as well as other higher-education institutions. Their sponsorship of scholarships, grants, programs and campus infrastructure allows students and faculty to pursue educational goals through community service.

ACADEMY FELLOW 2020

Doran Baker, PhD

Dr. Doran Baker is Full Professor in the Electrical & Computer Engineering Department at Utah State University of Agriculture & Applied Science. He is Co-Founder & Co-Director of the Rocky Mountain NASA Space Grant Consortium. Dr. Baker is serving as major professor &/or prime sponsor for 17 PhD students & numerous MS or MA students, & has been instrumental in the financial/program support of an additional hundred PhD & MS/MA students. He founded the space research program at Utah State University that has endured for decades & earned both national & international renown. He continues to develop a systems engineering & space instrumentation course sequences to help NASA & her contractors to meet workforce needs in areas that have become critical. He has authored a dozen books & hundreds of professional publications. Finally, Dr. Baker has been an essential part of the Utah Academy of Sciences, Arts, and Letters from 2011 to 2019, serving as the Engineering Division Chair. His years of service and commitment to the Utah Academy are deeply appreciated. He has been a wonderful friend and colleague over the years, and we are excited to honor him tonight.

O.C. TANNER LECTURE**“The Lion of the Road: Brigham Young and the Transcontinental Railroad”****Gene Sessions, PhD***Weber State University*

When the famous Golden Spike ceremoniously united the rails of the Transcontinental Railroad at Promontory Summit, Utah, on May 10, 1869, conspicuously absent from the pageantry of the day was the great Mormon Prophet Brigham Young, arguably the most powerful man in the West. Some have assumed from this, as well as his desire to isolate his followers from the profane world, that Young had opposed the Pacific Railroad and resented its coming through his Great Basin Kingdom. In fact, Young was among the Railroad's earliest and most influential boosters. Not only did he do all in his power to assist particularly the Union Pacific, providing crucial cooperation and labor as the road came into Utah, but he also moved quickly and effectively to accommodate his followers to the coming of the railroad without sacrificing his principles and objectives. This lecture will outline both Young's prominent role in building the Transcontinental Railroad and the actions he then took to protect his followers from the worldly dangers the railroad inevitably threatened while nevertheless enjoying its benefits.

See the accompanying paper on page 19.

JOHN & OLGA GARDNER PRIZE

The Gardner Prize is awarded annually for exceptional achievement by an academic professional in Utah.

Gene Sessions, PhD

Weber State University

Gene A. Sessions was born and reared in Ogden, Utah, the son of a sheepherder and a farmer's daughter. He received his B.A. from Utah State University in 1970 and his Ph.D. from Florida State University in 1974. After working in the Church of Jesus Christ of Latter-Day Saints Historical Department in Salt Lake City he joined the faculty of Weber State College (later University) in 1975, where his outstanding teaching and scholarship have been recognized through numerous awards including the Crystal Crest Master Teacher Award, John S. Hinckley Fellow award and the Presidential Distinguished Professor award. He has been active throughout his career in faculty service and leadership roles include Chair of the Department of History and chair of Faculty Senate. Gene is widely respected for his scholarship of Utah and Mormon history. He is the author of seven books and numerous articles that have been published in such journals as *The Journal of American Folklore*, *Interamerican Review*, and *Utah Historical Quarterly*. His scholarly works include books on Jedediah Morgan Grant, Science and Mormonism, the Utah War, the Foreign Debt crisis of the 1930s, and a history of Utah International. He has been a consultant on documentaries and committees exploring the Utah War and the Mountain Meadows Massacre and is a past president of the Mountain Meadows Association. He is always in demand to lecture, give presentations, and lead field trips around the West. Gene has long been an excellent ambassador for Weber State and the State of Utah, giving his famous field trip along the Mormon Trail in Utah to hundreds of interested individuals. He has served as the program chair of the Utah War Sesquicentennial Committee and has received the Distinguished Service Award from the Utah State Historical Society. Finally, Gene is a Fellow of the Utah Academy of Science, Arts, and Letters, and has received the Academy's 2006 Distinguished Service Award.

HONORARY MEMBER 2020

Dave Buhler, PhD

The Utah State Board of Regents named David L. Buhler as the eighth Commissioner of Higher Education in 2012. Commissioner Buhler came to this position with a long history of service in higher education, state and local government, and business. For nearly twelve years prior to his appointment, Commissioner Buhler served as Associate Commissioner for Public Affairs with responsibility for government and media relations and overseeing the system's strategic priority of participation and outreach. He also served as Interim Commissioner for eight months in 2008. Commissioner Buhler taught as an Adjunct Professor of Political Science at the University of Utah from 1990 to 2006, and was a member of the University Of Utah Board Of Trustees from 1999 to 2000. Commissioner Buhler served twelve years as an elected official, including two terms as a member of the Salt Lake City Council (2000-2007), and one term as a Utah State Senator (1995-1999). He served eight years in state government including four years as Executive Director of the Utah Department of Commerce (1989-1992) and as a member of the staff of Governor Norman H. Bangerter (1984-89). A native of Salt Lake City, Dr. Buhler received Bachelor of Science degrees in History and Political Science from the University of Utah, a Master of Public Administration degree from Brigham Young University, and has earned a PhD in Political Science at the University of Utah. He is currently serving as a visiting professor in the Political Science Department at the University of Utah. He is married to the former Lori Goaslind; they are the parents of five children.

2019 BEST PAPER AWARDS

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¹*Salt Lake Community College*, ²*University of Utah*

The Lion of the Road: Brigham Young and the Transcontinental Railroad

*O.C. Tanner Lecture, UASAL Annual Conference
Weber State University, March 23, 2019*

Gene Sessions

Weber State University

When the famous Golden Spike ceremoniously united the rails of the Transcontinental Railroad at Promontory Summit, Utah, on May 10, 1869, conspicuously absent from the pageantry of the day was the great Mormon Prophet Brigham Young, arguably the most powerful man in the West. Some have assumed from this, as well as from his desire to isolate his followers from the profane world, that Young had opposed the Pacific Railroad and resented its coming through his Great Basin Kingdom. In fact, Young was among the Railroad's earliest and most influential boosters. Not only did he do all in his power to assist particularly the Union Pacific, providing crucial cooperation and labor as the road came into Utah, but he also moved quickly and effectively to accommodate his followers to the coming of the railroad without sacrificing his principles and objectives. This lecture will outline both Young's prominent role in

building the Transcontinental Railroad to bring its benefits to his disciples and also some actions he then took to insulate his followers from its worldly dangers.

The sesquicentennial of the Golden Spike event coming in just a few weeks has heightened interest in one of the most dramatic events in the history not only of the United States but of the modern world: *Nothing Like It in the World*, renowned historian Stephen Ambrose titled his very readable book on “the men who built the Transcontinental Railroad.”¹ Among those builders was none other than Brigham Young, strangely enough perhaps the most famous among the remarkable set of men who dreamed, planned, labored, connived, bribed, cheated, bullied, and willed the thing into existence against enormous odds and genuinely incredible obstacles. While few (except maybe contestants on *Jeopardy!*) would recognize the names of Thomas “Doc” Durant and Grenville Dodge, who led the stringing of the Union Pacific west across the Great Plains from Omaha, or those of the “Big Four,” who forced the Central Pacific east through the rugged Sierras from Sacramento, Young left a larger mark on American history as “the American Moses” who forged a “Great Basin Kingdom” in the midst of the Mexican Cession. His controversial reign as the famously polygamist prophet/leader of the Mormons, from 1844 to 1877, has elicited several respectable biographies (some more or less so) and countless other publications dealing with his seemingly limitless impact on western history.² So, let us begin this morning with some comments about the man his followers called “The Lion of the Lord.”

Young came from the common, hard-scrabble frontier stock of early 19th-century New England. In his early thirties, while making his living as a carpenter and furniture maker, he came into contact with missionaries of what became The Church of Jesus Christ of Latter-day Saints. Reluctantly becoming a proselyte of the new religion, he then became completely devoted to it, especially after meeting its charismatic founder, the visionary Joseph Smith, who although some five years Brigham’s junior, immediately claimed Young’s undying devotion. Rising quickly to a place in Smith’s inner circle, he would eventually claim leadership of much of the movement following the Prophet’s assassination in 1844. Responding to Smith’s vague ideal of moving his people to the Rockies, and facing growing persecution in the middle Mississippi Valley, Brigham organized and directed for the next three decades the mass movement into the West of thousands of Mormons mostly from the eastern United States and from Europe. Between his first venture into the Salt Lake Valley in the summer of 1847 and the completion of the Railroad in 1869, more than 70,000 Mormons answered his call to gather to

the new Zion and walked 1,000 miles to the eastern edge of what geologists call the Basin and Range Province. Soon overflowing into neighboring provinces, these “first domesticators of the wilderness,” as Alistair Cooke dubbed them,³ settled more than 400 communities in the arid West to create a dominant Mormon culture hearth that spreads today across much of the intermountain region.⁴

This dynamic of 19th-century Mormonism is what brings us to our topic of Brigham Young and the Transcontinental Railroad. Young and his followers were devoted millenarians in the sense that they believed not only in the Second Coming of Christ to usher in the Millennium but also that such an event was imminent. They had not joined the likes of William Miller in predicting the date, but they were convinced that preparations for it were urgent, so their task was to build the Kingdom of God through a gathering of the “House of Israel” from the four corners of the earth. Even during the most trying years of their sojourn in the Midwest and then in the Great Basin, they sacrificially expended great energy, expense, and effort in spreading the Mormon gospel and urging its converts to emigrate to Zion. (This “Gathering” requirement, by the way, did not end until later Mormon President David O. McKay announced in the 1950s that Mormons are supposed to stay where they are and build the Kingdom there.⁵) With this imperative to gather and the enormous costs and difficulties of thousands of emigrants “crossing the Plains” in mind, Brigham Young understandably became an early and energetic proponent of a railroad across the continent to ease the process. He sent memorials to Congress in 1852 and again in 1854 urging the government to take action to get it done.⁶ So, years before Grenville Dodge convinced railroad lawyer and presidential candidate Abraham Lincoln at Council Bluffs in 1859 to become what Ambrose called “the number-one proponent and supporter of the railroad,”⁷ the Mormon leader had already signed his name near the top of that list.

To indicate that Young’s cooperation and support of the Railroad was crucial to its success is a ridiculous understatement. In their often-lunatic race to lay the most track, both Central Pacific and Union Pacific officials and functionaries understood this reality from the moment it became clear that the Pacific Railroad would cross through the Mormon Kingdom. Even the most strident anti-Mormons and venomous Brigham-haters knew the truth of what Alfred Cumming supposedly said to Young when he succeeded him as governor of Utah Territory in 1858: “I am the governor of the Territory, but you are the governor of the people.”⁸ Perhaps no one in American history has had such monolithic control over his people as did Brigham Young. In a scathing editorial in 1868, the *Cheyenne Daily Leader* lamented that he would have his way with the Railroad, because “there is more political strength and influence

united in him than in any other one person in America.”⁹ Here is an example to the point of all this: When Young finally surrendered to the reality that Ogden and not Salt Lake City would become the “Junction City,” he moved forcefully to assure that the Mormon town and not some other spot up the line (as the Union Pacific hoped) would get the title. On New Years Day 1869, he met with the landowners of five-acre parcels just west of the city where the railroad wanted to build its rail yard. He “offered” these faithful \$50 an acre for land well worth four times that. Out of deference to their leader, all of them obediently agreed, although as it turns out very reluctantly. Ogden historian Val Holley has quipped that “barely was the ink dry on Brigham’s death certificate in 1877 than the landowners immediately petitioned the city and county governments for some extra compensation for their land.” Eventually, they got an additional \$50 an acre as a reparation from local government.¹⁰

While we are on this subject, and inasmuch as we are in Ogden, let there be no doubt that Young was sorely unhappy when officials of the two railroad companies met in Salt Lake City on August 14, 1868, and agreed finally on the northern route around the Great Salt Lake thus bypassing the Mormon capital. Grenville Dodge got the difficult assignment of meeting with the bearded patriarch to deliver the news. The general later reported that Brigham “was greatly disappointed and much dissatisfied” and threatened to withdraw support from the Union Pacific, but, as David Bain argues in his excellent history, *Empire Express* (1999), “Young was too astute a businessman to see any benefit in hostility or obstruction. . . .”¹¹ Two days later, Brigham addressed the faithful in the newly completed domed Tabernacle on Temple Square. Dodge claimed that he sat with his wife and children while the Mormon prophet roundly denounced him for the decision and proclaimed a revelation that the northern route would not be safe. In addition, Dodge said that in the aftermath of the sermon, he received warnings that he needed to get out of town in a hurry.¹² (So, Dodge needed to get out of Dodge!) Anxious to believe such tales of the murderous inclinations of Brigham and his minions, many writers have picked up this story and repeated it until it has become “fact.” Actually, a transcript of Young’s long-winded sermon that day reveals a generally routine and prolix assault on lazy elders and disrespectful Saints, and then a hour-long appeal for more missionaries. With regard to the choice of the northern route, about all he said was that it was an insult to the Latter-day Saints, but, he added,

We don’t care about it, we are in the habit of being insulted and imposed upon. Far from wishing not to have a railroad it ought to have been built years ago. When we came to this valley we

never traveled a day without marking the path for the road to this place. We anticipated it, and if they had done as they should have done, instead of going to war and killing each other, we should have had a railroad long ago. These are my feelings with regard to the railroad, and whether it comes through this city or not is all right, because God rules and He will have things as He pleases. We can act but He will over-rule.¹³

So he accepted the decision to bypass Salt Lake City with “disappointed acquiescence,” as Bain puts it,¹⁴ and continued to work diligently to contract for as much labor as he could arrange, often enticing both companies with promises for preferential treatment. He wound up contracting directly only with the Union Pacific, in which he had invested \$5,000 (1862) and served as a director, but he shrewdly arranged for three Mormon elders in northern Utah, Apostle Ezra Benson, Bishop Chauncey West, and Ogden Mayor Loren Farr, to deal separately with the Central Pacific. Brigham signed in May 1868 a contract with the Union Pacific for \$2,125,000 for work on the line from Echo to the Great Salt Lake, and his friends contracted with the Central Pacific for some 200 miles from Humboldt Wells to Ogden. In the end, the great majority of the grading for track in eastern Nevada and Utah for both companies happened under contract either to Young or to his three cohorts with literally thousands of Mormon laborers doing most of the work.¹⁵ As a result, as Holley reports, real cash began to show up in northern Utah for the first time in months if not years.¹⁶

This suggests that without question, Brigham Young had other reasons for supporting the Railroad beyond assisting emigrants to come to Utah. Being the “astute businessman” that he was, he saw plenty of opportunity for him, his family, his friends, and most importantly his followers in general to make money and improve their standard of living. Indeed, a biblical plague of grasshoppers had descended on modern Israel, bringing the agrarian Mormons to the brink of literal starvation economics as crops failed even as the two rail lines approached from east and west. Young characterized the contract for labor he had negotiated with the Union Pacific to be a “God-send:”

There is much indebtedness among the people, and the territory is drained of money, but labor here and coming we have in large amount, and this contract affords opportunity for turning labor into money, with which those here can pay each other, and import needed machinery, and such useful articles as we cannot yet produce, and those coming can pay they indebtedness, and

have ready means with which to gather around them the comforts of life in their new homes.¹⁷

Now late in his seventh decade, the stout Mormon patriarch seemed to realize from the beginning of his relationship with the builders of the Railroad that he was in bed with some commonly devious and conniving men. Although many of them found him “ridiculous” or “disgusting,” all of them realized as beyond essential his involvement in the successful completion of the Road once it got into his realm. As a result, even as they demeaned him and his people behind his back, they all tread very carefully when they had to deal either with him directly or with his agents. They routinely fawned over him and pursued his favor in often-surprising ways. For example, when Governor Leland Stanford, one of the fabled and powerful “Big Four” of the Central Pacific company, came to see Young in August 1868, he discovered that the prophet had left the city to visit some northern settlements. Rather than wait for his return, Stanford chased after him. When he caught up with him, the California governor discovered that he could not persuade Young to contract with the Central Pacific but that Brigham’s three brethren, Benson, West, and Farr, would be happy to do so. It seemed that, in the brutal game of chess the two companies were playing with each other, the Mormon leader was not going to be a pawn in either’s hand.¹⁸

Some critics of Brigham Young have accused him of promoting the Railroad primarily to enrich himself, his family, and friends. While it is certainly true that he positioned himself, some friends, and three of his sons to profit handsomely from the Road, Railroad historians repeatedly conclude that these charges hold little water in comparison with his clear objectives of providing financial relief to the struggling Saints and to making it easier for converts to emigrate to Zion. In virtually every conversation with company officials and in his public and private pronouncements, Young emphasized the boon to the Perpetual Emigrating Fund, for example, and the money that would land in the pockets of the Mormons who labored on the Road. He pressed for reduced rates on the completed line for Mormon families and quick and adequate payrolls for his workers, while consistently repeating what he viewed as the great advantages to his people that the Railroad would bring with it. He even convinced Doc Durant to provide free passage over the Union Pacific for “quite a good many Mormons coming from Europe this year.”¹⁹ The evidence is overwhelming, it seems to me, that Brigham Young was relentless in working to build the Road not for his own benefit but for the ultimate welfare of his followers.

So, while there can be little question that the leaders and functionaries of both companies knew they had met their match in Brigham

Young (and dealt with him accordingly), there is also little doubt that they nevertheless viewed him and his followers as “mostly ignorant and superstitious and bigoted, without education,” as one Union Pacific agent wrote to Dodge’s wife Anne, “easily handled by so cunning an old rascal as Brigham Young and his lieutenants.”²⁰ Polygamy, of course, offended everyone who had to visit Salt Lake City and pretend to respect its denizens. Surveyor Butler Ives labeled the Mormons’ peculiar institution “abhorrent to the finer feelings of any educated person.”²¹ Most of these folks nevertheless expressed grudging admiration for what the Mormons had done with the Salt Lake Valley through their agriculture and industry.²² What really impressed them was the work the Mormon laborers performed once they got into the grading and tunneling business. General Dodge, once Brigham’s men got to work, “couldn’t have enough Mormons working for the UP.” He loved to watch them at work and at rest: “They were teetotalers to the last man, tolerated no gambling, were quiet and law-abiding, said grace devoutly at meals, and concluded each day’s labor with communal prayers and songs.”²³ A favorite was this one:

At the head of great Echo
The railway’s begun
The Mormons are cutting
And grading like fun
They say they’ll stick to it
Till it’s complete,
When friends and relations
They’re longing to meet.²⁴

“A people working together in harmony,” one historian described them, “under the guidance of their religious leaders to accomplish a temporal task which they treated as though it were divinely inspired.”²⁵ As another Mormon song put it,

Hurrah, hurrah, the railroad’s begun.
Three cheers for the contractor, his name Brigham Young.
Hurrah, hurrah, we are faithful and true
And if we stick to it, it’s bound to go through.²⁶

“It was acknowledged by all railroad men,” Hubert Howe Bancroft wrote in 1890, “that nowhere on the line could the grading compare in completeness and finish with the work done by the people of Utah.”²⁷

In the end, Dodge and the others were able to pay for some of the massive amount of labor under contract with Brigham Young (who made up for much of the rest from his own pocket), but they defaulted on just

about everything else. Even though Young had been the only investor in the line to pay in full his \$5,000 subscription back in 1862, when all the singing and celebrating ended, the Union Pacific had gone into virtual bankruptcy and stiffed the Mormons and everyone else with equal abandon. Rampant corruption at all levels (that would boil up into the national Credit Mobilier scandal) along with the dishonesty and thievery of literally every contractor except Brother Brigham drove down the Union Pacific like a rusty spike in a rotten tie. Undaunted, the bullheaded old patriarch immediately began a campaign to get the company to pay what it owed his church and his people. Finally weary of his constant pressure, the Union Pacific in September 1869 delivered to the church 4,000 tons of iron rail worth almost half a million dollars, 144 tons of spikes (\$20,000), thirty-two tons of bolts (\$5,600), four first-class passenger cars (\$20,000) and an incredibly long string of additional rolling stock worth an immeasurable amount. Using this bounty, the Mormons immediately began work on the Utah Central from Ogden to Salt Lake and had it running in a few months.²⁸ So, Brigham Young got what he wanted after all, a railroad into Salt Lake City, and his people rode away from the whole messy business with considerable compensation for the crucial part they had played in uniting the nation with the Golden Spike.

In the midst of this single-minded desire to get the Transcontinental Railroad completed so his followers could enjoy its benefits, Young also worried about how it might disturb his ideal of a self-sufficient society—necessarily a part of but at the same time apart from the rest of the world. He realized that while the Railroad would speed the arrival in Zion of Mormon converts, it would also inevitably invite more Gentiles to come to Utah as well. Particularly worrisome was the likelihood that the Road would facilitate the rapid growth of a powerful non-Mormon business community. Concomitantly, his Saints would become accustomed to imported goods while his dream of an economically self-sufficient community faded away. “Brigham’s first and most persistent response to the economic challenge,” wrote biographer Leonard Arrington, “was jaw-boning, a stepped-up campaign to discourage the purchase of imported luxuries. Included in the ban were tea, coffee, alcohol, and tobacco—items proscribed by Joseph Smith’s ‘Word of Wisdom’ [health code]—and also fashionable clothing and elegant furniture.”²⁹

Young also realized that the Road would increase dramatically Utah’s mineral production. Other than iron and coal that would aid in the building of self-sufficiency and economic independence, Brigham had forcefully discouraged “hard-rock” mining in the Territory. This left that enterprise in the hands of his nemesis Patrick Edward Connor, who had come to Utah in 1862 with a company of California volunteers to keep an eye on the Mormons.³⁰ Mustered out of the Army at Camp Douglas

as a brevet major general in 1866, Connor turned his full attention to fostering gold and silver mining. Within a year of the arrival of the Railroad into Utah, Connor's efforts really took off, as the production of non-ferrous metals in Utah rose from less than \$200,000 per year to \$1.5 million.³¹ The Mormon leader seemed resigned to this development but continued to discourage his followers from participating in it other than encouraging them to sell agricultural products to the miners and in other ways to benefit indirectly from the booming mining industry, including welcoming the abundance of hard money that the mines generated for Utah's economy.

Anticipating inevitable social and economic changes, Young established a "School of the Prophets," a group of church leaders to plan for a multifaceted program to blunt the negative effects of the Railroad, including helping Mormons secure property titles against the threat of non-Mormon takeovers, the establishment of local manufacturing and merchandising cooperatives, and boycotts of hostile Gentile businesses. To keep as much of the economic engine in Mormon hands, he built first the 37-mile Utah Central from Ogden to Salt Lake City and then initiated construction of a number of "Mormon roads," including the Utah & Northern into Idaho and eventually to Dillon, Montana, and the Utah Southern almost to Beaver, with branch lines serving many of the mining districts along the way. These lines were not profitable but kept Young and his associates in firm control of railroad traffic in the intermountain region. The Union Pacific later purchased these roads, but not before the Mormons had stamped "Holiness to the Lord" on the rolling stock and bridges to remind the Gentiles who controlled commerce in the area.³²

Perhaps the most dramatic move Young made on the economic side as the Railroad came to Utah was his creation of Zion's Cooperative Mercantile Institution (ZCMI), "America's first department store," along with local cooperative general stores, to channel imported consumer goods through Mormon hands. He also organized numerous other banking and manufacturing companies across the Territory.³³

To reinforce the social bulwark against non-Mormon influences, he reorganized the "Female Relief Society" Smith had created in Nauvoo but that had gone dormant since his murder. One of Brigham's "caretaker wives," Eliza R. Snow, became its new president. The two added to its traditional charitable mission the tasks of preventing or diminishing female extravagance, educating women on political matters, mustering their support against anti-Mormon legislation, and developing a women's commission store to sell handicrafts and home manufactures. The old patriarch was particularly concerned that the railroad would multiply "the influence of Babylon on women's fashions,"³⁴ so he condemned with specificity contemporary trends that required "most

useless, unbecoming, and ridiculous” amounts of cloth. Instead, he argued, women should eschew such expensive temptations and spend the money on bringing more Saints to Zion.³⁵

In addition to the resurrection of the Relief Society after an absence of 25 years, Young organized within just a few months of the Golden Spike his own teenaged daughters into what he called the Young Ladies Department of the Cooperative Retrenchment Association. As the idea spread through the Church, it soon became the Young Ladies’ Mutual Improvement Association³⁶ and eventually the Young Women’s program that still exists today. Its aims and goals are not much different than they were when its first meetings convened in Utah with the whistles of railroad locomotives newly evident in the distance—modesty, decency, virtue, cleanliness, and devotion to traditional womanly endeavors.

As an intellectual wall against the incoming world, Young jump-started the University of Deseret that had been gathering dust since its original establishment in 1850. Under the able leadership of John R. Park, a physician who had come to Utah during the Civil War, the school enrolled 223 students in 1869, nearly equally divided between men and women. Brigham ordered Park to teach all the usual curricula of the colleges of the era, but with a de-emphasis on the classics and “dead languages” that he believed were a tool designed “by the learned to keep the unlearned in subjection and ignorance.”³⁷ A spillover from this effort was a movement to establish free public schools in Utah. Young instructed bishops to maintain schools in their wards, the costs borne by the parents, but many Mormons and Gentiles shared the belief that public funds and supervision should form the backbone of primary and secondary education. By the time Brigham died in 1877, the legislature was well on its way to establishing a public school system in the Territory.³⁸ Also confronting numerous Protestant and Catholic schools sprouting within its domain, the Church responded with the creation of numerous stake academies, including the descendant of one of them in which we now meet.³⁹

Few realize that it was the coming of the Transcontinental Railroad that stimulated such wide-ranging and profound changes in Utah and in its predominant culture, beyond just the realm of economics. Historians generally dislike the notion of inevitability—the Historical Determinism of a Marx or a Hegel—but they are also suspicious of the certain influence on the course of history of powerful actors—the Great Man Theory à la Thomas Carlyle. Perhaps the truth is somewhere in between those extremes, but it seems clear when it comes to the history of the great Pacific Railroad that Brigham Young represents a strong case for someone who acted with remarkable strength and will to shape the inevitable to his will and to the benefit of his people. We learn a great deal about

the famous Mormon from his involvement in the building of the Railroad. I find it not only profoundly interesting but highly instructive about the kind of man he was—complicated, tough, doggedly single-minded, shrewd, wily, perhaps a bit devious, and certainly Machiavellian. His harsh critics, such as recent biographer John Turner, look at these attributes and conclude that he was at heart a rather nasty character who happened to have some excellent leadership skills. It seems to me, however, after studying him as a major player in the building of the Transcontinental Railroad, that he indeed had incredible management talents but that his motives were far from ignoble. I have been studying him and his legacy for nearly half a century, and this excursion into this chapter of his life and the history of Utah has led me to some fresh insights that bring both him and the history of the Railroad into sharper focus. I hope it has done the same for you.

Notes

1. Stephen E. Ambrose, *Nothing Like It in the World: The Men who Built the Transcontinental Railroad, 1863-1869* (New York: Simon & Schuster, 2000). Ambrose devotes Chapter 13, “Brigham Young and the Mormons Make the Grade,” to heaping lavish praise and little criticism on the Latter-day Saints and their leader for their crucial role in building the line through Utah. There is a plethora of work on the Transcontinental Railroad, but the author has used as secondary sources for this article primarily Ambrose and David Haward Bain, *Empire Express: Building the First Transcontinental Railroad* (New York: Penguin Books, 1999). Bain and Ambrose each express almost universal approbation both of Young and of his followers during the building of the line, in terms of motivation and diligence. The source most critical of virtually everyone involved, including the Mormons, is “New West” Historian Richard White, *Railroaded: Transcontinentals and the Making of Modern America* (New York: W.W. Norton & Company, 2011).

2. Among the many treatments of Young’s life, two stand out as most complete, well-researched, and fully developed: Leonard J. Arrington, *Brigham Young: American Moses* (New York: Alfred A. Knopf, 1985), and John G. Turner, *Brigham Young: Pioneer Prophet* (Cambridge: Harvard University Press, 2014), present widely divergent views of the Mormon leader. Arrington, a former Utah State University professor who served for some time as the LDS Church’s official historian with full access to church archival holdings, portrays Young in largely favorable terms as a beloved yet iron-willed ecclesiast possessive of

remarkable leadership abilities. Turner, an ordained Protestant minister who teaches history at George Mason University, reveals a much more flawed and hard-boiled autocrat whose “vindictiveness” often led to considerable “hardships for his people.” Even more harsh is Stanley P. Hirschon, *The Lion of the Lord, a Biography of Brigham Young* (New York: Alfred A. Knopf, 1969), but its credibility suffers greatly with the author’s outrageous boast that he felt little need to consult primary source material “in the Rocky Mountains.” Perhaps the most balanced view of Young is Newell G. Bringhurst, *Brigham Young and the Expanding American Frontier* (New York: Little Brown & Company, 1986), a part of the Pearson Library of American Biography series and thus painfully brief.

3. Alistair Cooke, *America* (New York: Alfred A. Knopf, 1976), 223-24.

4. See Eugene E. Campbell, *Establishing Zion: The Mormon Church in the American West, 1847-1869* (Salt Lake City: Signature Books, 1988). See also Wallace Stegner, *The Gathering of Zion: The Story of the Mormon Trail* (New York: McGraw-Hill, 1964), and Stegner, *Mormon Country* (New York: Hawthorn Books, 1942).

5. See Gregory A. Prince and William Robert Wright, *David O. McKay and the Rise of Modern Mormonism* (Salt Lake City: University of Utah Press, 2005), particularly Chapters 9 and 14. “Following the turn of the century, the church quietly deemphasized the policy of ‘gathering,’ although it would be another half-century [under McKay] before it openly reversed the policy and encouraged people to stay where they were and to build the church there.” *Ibid.*, 299.

6. Arrington, *Brigham Young*, 348.

7. Ambrose, 193.

8. Sermon by Brigham Young, 10 February 1867, *Journal of Discourses*, 26 vols. (London, 1854-86; reprint ed., Salt Lake City, 1967), 11:324.

9. Quoted in Ambrose, 285.

10. Val Holley, “The Coming of the Transcontinental Railroad to Ogden, March 1869,” (lecture, Weber Historical Society, Ogden, UT, 11 March 2019.).

11. Bain, 532.

12. *Ibid.*, 533. Bain cites Dodge's *Autobiography* located in the Council Bluffs Public Library, 801-2.

13. *Deseret Evening News*, 17 August 1868.

14. Bain, 533.

15. See Robert G. Athearn, "Contracting for the Union Pacific," *Utah Historical Quarterly* 37 (Winter 1969): 17-28. For Central Pacific contracting with the Mormons, see Ambrose, 290-92.

16. Holley lecture.

17. Young to F.D. Richards, 23 May 1868, quoted in Leonard J. Arrington, *Great Basin Kingdom: An Economic History of the Latter-day Saints, 1830-1900* (Cambridge: Harvard University Press, 1958), 262.

18. Bain, 537.

19. *Ibid.*, 495-96.

20. *Ibid.*, 398.

21. *Ibid.*

22. *Ibid.*

23. Ambrose, 286.

24. Quoted in *Ibid.*, 286-87, and Bain, 559.

25. Wesley S. Griswold, *A Work of Giants: Building the First Transcontinental Railroad* (New York: McGraw-Hill, 1962), 254.

26. Quoted in Ambrose, 287, and Bain, 559. Bain reports that this song was the chorus to the first passage quoted above. Their two versions of the song(s) also differ slightly. Ambrose cites evidence that it was written by James Crane, a Mormon railroad grader, while Bain repeats it from the memory of a farmboy named W.C.A. (Bill) Smoot.

27. Hubert Howe Bancroft, *History of Utah* (San Francisco: History Company, 1890), 754.

28. Ambrose, 372-73. See also Athearn, 30-40, and Bain, 660.

29. Arrington, *Brigham Young*, 348.

30. See Brigham H. Madsen, *Glory Hunter: A Biography of Patrick Edward Connor* (Salt Lake City: University of Utah Press, 1990).

31. Arrington, *Brigham Young*, 349.

32. *Ibid.*, 349-50.

33. *Ibid.*, 350-51.

34. *Ibid.*, 351.

35. *Ibid.*

36. *Ibid.*, 352-53.

37. *Ibid.*, 353-54.

38. *Ibid.*, 354-55.

39. Richard W. Sadler and Richard C. Roberts, *History of Weber State College* (Ogden, UT: Weber State College, 1988), 2-4. Sadler and Roberts list 22 colleges and academies the Church had established by 1911.

Japanese Ideals in Michio Ito's Choreography and Technique

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Abstract

Cultures create different values and ideals that help them make sense of the world. By studying aspects of specific dances, it is clear that dance reflects culture. This research will show, through a New Historicism perspective, that Michio Ito's choreographic philosophies and works are reflective of Japanese cultural ideals. Japanese cultural values and ideals are vital in the society, as they are seen in every aspect of the citizens' lives. These ideals include Makoto, Yugen, Iki, and In-Yo. Understanding these ideals will create a deeper understanding of dance in Japan. Michio Ito is most known for the creation of his technique, "Ten Gestures." This was the basis of his creations such as the Scriabin Preludes. By analyzing these examples of Japanese ideals alongside Ito's choreographic works, it is evident that the products and values of a culture are profoundly reflected in dance.

Every culture creates different values and ideals that help its citizens make sense of the world. These values are the products of the culture, and the citizens are strongly influenced by them since they are creating and maintaining them. New Historicism is a postmodern frame of analysis that connects any work to its original time and place of its

creation, thus providing insight into the culture through what the citizens value (Brizee, “New Historicism”). Dance is a product of a culture, and by studying its essential aspects, it is clear that dance reflects culture (Adshead-Lansdale and Layson 8). The Japanese culture makes sense of the world through their created values and ideals. Cultural values and ideals are seen specifically in art, religion, and architecture. These were created to shape the understanding of citizens of Japan and what they believe. Many Japanese cultural ideals have to do with complementary opposites working together to make a whole. Another takeaway from these ideals is the sense of loyalty: never straying from one’s true self. These Japanese values and ideals will reveal what the Japanese culture is like and how it is understood. The understanding of said ideals will identify what dance influenced by Japanese culture looks like, specifically dances created by Michio Ito, a Japanese artist. It will be understood that dance coincides with cultural ideals because dance reflects culture (Adshead-Lansdale and Layson 8). Ito’s technique, “Ten Gestures,” was the basis of his creations such as *Scriabin Preludes*. These works showcase many Japanese cultural values and ideals that Ito was influenced by. This research will show that through a New Historicism perspective, it is evident that Michio Ito’s choreographic philosophies for *Scriabin Prelude #V (Prayer)* and *Scriabin Preludes #VI (Warrior)* have a strong influence of Japanese cultural ideals.

New Historicism is a frame of analysis that connects an event or work to the original time period and location in which it was produced (Brizee, “New Historicism”). It shows how the work, in this case, dance is a direct reflection and product of the culture by looking at several aspects of the culture (Adshead-Lansdale and Layson 12). These aspects include political, economic, religious, intellectual, and artistic ideals that emerge from a culture during the specific time. By analyzing the aspects of a culture through the New Historicism perspective, identification and knowledge of how the work reflects the cultural values are available (Brizee, “New Historicism”). This frame seeks to connect a work with the culture through a series of questions to reveal the connections to culture found within a work (Brizee, “New Historicism”). A dance can be analyzed to see if it is a product of the culture, if the elements of the dance change over time, and if it supports the cultural events of the time. In a broad sense, the main goal of New Historicism is to create new knowledge revealing that dance is a reflection of culture. If dance reflects culture, analyzing different Japanese cultural ideals will help in understanding the culture and its dances.

New Historicism is related to structuralism, which is another post-modern frame of analysis. Structuralism suggests that all systems/cultures are symbolic and subject to their own rules, which are a product of

their culture (Brizee, "Structuralism"). Each culture has different "rules" by which they abide. The Japanese culture is no exception to this. Some of the rules and ideals that have been produced by Japanese culture are Makoto, Yugen, Iki, and In-Yo. These ideals are found all throughout their culture, but especially in the arts, religion, and architecture (Parkes). Makoto, translated to mean sincerity and truthfulness, is considered one of the most important ideals in Japanese culture. It centers on the basic notion of telling the truth with your whole being. It is also described as a "singleness of mind," in the sense that everything points in one direction; there are no discrepancies in one's life. This ideal mainly comes from Confucianism, one of Japan's most dominant religions. Confucianism states that one's outer self and inner self should be in a corresponding relationship. Inner feelings should be the same as one's outward actions (Reasoner). An example of Makoto in Japanese culture are haiku poems. Each word and syllable in the haiku connects to an overlying theme. There are no discrepancies in any sentence; each individual part stays sincere to the theme (Reasoner).

Another Japanese cultural ideal is Yugen, meaning profound grace. Yugen, in this sense, refers to the results of a pattern of rigorous discipline (Parkes). It is essential to many performing arts in Japan such as the tea ceremony, calligraphy, and theater. There is a specific way of doing these actions and/or ceremonies. It is also important in all martial arts, as there are particular gestures and movements in each style. A specific category of Yugen is Nō. Nō alludes specifically to dance and music. Both arts are considered admirable in this respect, because of their discipline and rigor (Parkes). Dance, in Japan, is held in this regard because it corresponds with the Yugen ideals. It includes diction, gestures, gaits, and dance movements that are all highly stylized.

Iki, another cultural ideal, is a phenomenon that is central to Japanese aesthetic life (Parkes). Iki deals with opposites in aesthetic feelings, e.g., sweet vs sour, light vs dark, flashy vs quiet, or male vs female. An example of Iki in Japanese culture is seen in their architecture. An example of this is a small Zen tea house that is made out of two contrasting materials, wood and bamboo. The two different materials work together to create something whole, a house. There are other ideals that are very similar to that of Iki, being that it is the central philosophy of Japanese aesthetic. One of these includes the philosophy of In-Yo. In-Yo is the Japanese variant of the Yin-Yang of Chinese culture (Milcinski). In-Yo, similarly to Iki, has to do with complementary opposites coming together to create a whole. "In" is symbolic of femininity, passivity, the moon, etc., whereas "Yo" represents masculinity, activity, the sun, etc. The duality of both parts helps create a "Oneness." One part cannot exist without the other (Milcinski). The cultural values of Yugen, In-Yo, and Iki

are central to Japanese values and provide an insight into interpreting Ito's work as reflective of the culture.

It is evident that Japanese ideals are a product of the culture. Sincerity and truthfulness is the sense of being one's true self and is seen especially in religion in Japan. *Yugen* is the sense of profound grace from rigorous practice. It is an important value in martial arts, tea ceremonies, dance, and music. *Iki* and *In-Yo* are very similar, in that they both deal with opposite parts coming together. If dance reflects the culture and knowing the culture helps in understanding dance, then looking at Ito's *Scriabin Preludes* through a New Historicism perspective can reveal Japanese cultural values.

Michio Ito (1893–1943) is known for his technique of “Ten Gestures.” The basis of all his choreography is built upon this technique (Caldwell 143). He compared his Ten Gestures to the 12 notes on a piano, each one being essential to creating a piece. The combination of gestures makes beautiful compositions and an endless variety of movement. In Ito's technique, there are two different forms entitled “A” and “B”/“masculine” and “feminine” (Caldwell 143). Each gesture is numbered and is extremely specific and direct. They are linear and smooth, with each one flowing into the next, constantly moving. Ito believed that the arms and head were the best way for the body to portray a specific idea. When the gestures are being practiced in singularity, there is a defined way and order to practice them. Correct performance is essential to the Ito work. When put into choreography, the gestures are then manipulated and given a different order. One arm may be doing a completely different gesture than the other arm (Caldwell 144). This manifests the endless variety that is seen in Ito's work.

The “Ten Gestures” are very direct and have a set place. Along with an established destination of each gesture, the journey and transitions to these positions are also important. They are practiced in a bound and controlled flow with set breathing between each gesture. Set “A” (masculine) is open and strong (*Yo*). It starts with gesture ten, with both arms straight above the head in a “V” shape. The arms stay straight and come down diagonally to the sides of the body for gesture one. Following this, the palms face down, and the elbows initiate the movement to end facing out at hip level at gesture two. For gesture three, the hands continue to move up, and the palms hover over the breast with the elbows still out to the side. After this, the elbows drop to the side, and the palms are facing outward at armpit height for gesture four. The arms then push straight out from the armpits in gesture five and continue until the arms cross in front of the chest for gesture six. Gesture seven allows the elbows to initiate movement again until the palms are covering the eyes. The palms then face upwards, parallel to the ceiling for gesture eight. To finish, the

tips of one's fingers touch the hairline for gesture nine and end back in gesture ten, the "V", where they began. Set "B" (feminine) is more closed off and softer (In). It begins at gesture ten with arms straight above the head with hands touching and then lowering to the sides of the body to gesture one. The elbows initiate movement, and the hands end at hip height, but with the elbows facing the back in gesture two. The hands cover the breasts again, but with the elbows close to the body for gesture three. Following this, the elbows reach out to the sides, and the palms face outwards in front of the breast in gesture four. This continues, and the hands push directly side in gesture five. After completely extending, the arms cross in front of the chest for gesture six, and then the hands raise up to cover the eyes in gesture seven. The hands then reach in front of the face for gesture eight, to swoop backward for the fingers to touch the back of the head in gesture nine. Following this, there is another small swooping motion to bring the arms back to where they began in gesture ten. While a dancer completes these gestures, they aspire to continuously perfect the execution of their movement and breath (Yugen).

Ito's "Ten Gestures" technique is similar to the Japanese cultural philosophy of In-Yo. The In-Yo theory is the combination of two opposite parts that make a whole: light/darkness, fire/water, masculine/feminine, etc. (Taylor). Duality is an important part of In-Yo, implying that one thing cannot exist without the other. "Ten Gestures" has the masculine and feminine forms; they both coexist with each other in Ito's pieces. Although each form is different, they are used together to create the whole. Using his "Ten Gestures," Ito created different dance poems, which were pieces that succinctly portrayed a specific theme or mood. He created these to the compositions of Alexander Scriabin, particularly his preludes. The prelude dance poems premiered in the years 1927 and 1928. His particular goal for these works was to conform to the music, combining two separate works of art together holistically (Caldwell 7). Each of these preludes has a different theme and mood. The pieces being analyzed for this research are *Scriabin Preludes #V (Prayer)* and *#VI (Warrior)*.

Prelude #V and *Prelude #VI* are, as the titles suggest, about prayer and warriors (Caldwell, 7). Ito manipulated his "Ten Gestures," forms A and B, and used them to portray the different meanings of his pieces. *Prelude #V (Prayer)* was done as a female solo in Utah's Repertory Dance Theatre (RDT)'s performance of Ito's work. It is a short piece, less than two minutes long. Although short, it is filled with intriguing and meaningful movement. The piece is about a medieval page that goes to church to worship her patron saint. The page worships holy images and shows reverence (Caldwell 7). The reverent and holy movements were created by Ito from manipulations of the "Ten Gestures." Sarah

Donohue, the soloist who performed in *Prelude #V (Prayer)* for RDT, explained that many of the movements involved the hands being held together, as if in prayer, or held to the head, signifying thoughtfulness. In this piece, the entire body expresses prayerfulness. The arm gestures are very direct and light, which brings attention to what the dancer is “worshipping.” Donohue’s focus is also very clear, in that she spends several moments of the dance looking upwards in the direction of what she is worshipping or looking down in reverence. Many of the movements were also performed with bound flow, meaning that the energy of the movement was controlled and held in. She was peaceful and very calm as there were no wild, free-flowing, or uncontrollable movements. Donohue often retreats from her torso and kneels, again showing respect and reverence to what she is looking at and worshipping. She also does several light air moments with her torso advancing, as if she was seeing or communing with the higher power. Her palms are facing outward in many gestures, signifying an offering. There is a sense of dignity and loyalty in both the movement and music. The movement of this piece has connections to several of the Japanese ideals discussed earlier. The most similar ideals to the movement are Makoto and Yugen. Makoto is expressed by the “singleness of mind” or the direct focus of the dancer. Everything in the piece fit with the entire prayer/ecclesiastical theme of Ito’s dance poem, including the movement described above and the calming music. Yugen, or profound grace, is shown by the movements being highly stylized and specific. Sarah Donohue mentioned that the dance masters who came to teach the Ito technique were very strict in getting the gestures correct. There was a certain place where every body part needed to be. Yugen is also seen in that there are grace and unity in the music and in dance. Both are light and precise.

In *Prelude #VI (Warrior)*, Ito also used many manipulations from his “Ten Gestures” technique. This dance was done as a male quartet when performed by RDT. It is very different from *Prelude #V*, in that the movement is very strong. It is about the fierce and joyous love of a warrior. It is seen as a ceremonial dance for the warlord (Caldwell 8). There is a unison moment in the dance where all four men are advancing directly forward with strong arm gestures. Their bodies are sensitive to the music, stamping along with the rhythm and beat. Their shoulders and stance are broad and wide. They exude confidence and power from their torsos, as they are advancing toward the audience or wherever they may be traveling. They demand attention from the audience while commanding the stage space with a large psychological kinesphere, radiating pride and power. Their movement matches right along with the music. It is strong and demanding. The Japanese ideals of Yugen and Makoto make a strong presence in this dance poem as well. Yugen is seen again as the

movements are very specific to a theme, along with unity in the movement and music. The ideal Makoto is evident in that everything coordinates to the theme that Ito had envisioned. Looking at both dance poems, it is clear that they are very different from each other; they have different feelings and themes to them. Although separate, combined together they, and other pieces, create a whole concert of different themes. This is an ultimate example of Iki and In-Yo. In the RDT concert program, another company member, M. Colleen Hoelscher, stated that “this concert is about contrasts in our world, the fast-paced and the simple. The yin and yang [or In-Yo] of life: men and women, power and subtlety, performance and pedestrian” (7). It is clear that Ito was inspired by Japanese cultural ideals in his work and that his work is a product of the Japanese culture.

By looking at Ito's choreography through the lens of New Historicism, it was possible to create new knowledge by connecting Japanese cultural ideals, i.e., In-Yo, Iki, Yugen, and Makoto to Ito's techniques and his choreographic works, the *Scriabin Preludes*. The ideals Iki and In-Yo relate directly to Ito's two different sets of movement as well as the distinct pieces that would compile a concert. It portrayed the idea that two or more contrasting themes can be used together to create something whole. Yugen was seen in the precise movement of arms and body; it expounded on the idea of the rigor and discipline used in the performing arts, especially in gesture and diction. Ito's “Ten Gesture” phrases were very precise and required an extreme amount of discipline and exactness. Makoto was incorporated in giving a “oneness” to a dance, connecting everything to a theme with no discrepancies. By analyzing these examples of Japanese ideals alongside Ito's choreographic works, it is evident that the products and values of a culture are profoundly reflected in dance.

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Rethinking the Ecology of Islamic Geometric Ornament

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Abstract

Geometric ornament in Islamic art is often interpreted in a framework of alleged mystical symbolism. This paper is part of an ongoing project to rethink Islamic ornament and how we relate to it as human beings in the natural world. Building on recent thinking in psychology and neuroscience, I argue that the aesthetic appeal of geometric pattern comes from the sense of cognitive efficacy it affords. Recognizing a pattern means grasping that certain shapes will repeat at certain intervals. A geometric pattern thus provides a field of perceptual input in which the successful prediction of how the world is going to behave (at least in this context) is simple, almost effortless, and the feeling of having succeeded in its fundamental task is uniquely rewarding to human consciousness. The contrast with the difficulty of discerning pattern in the world of things and people, in turn, suggests an explanation for the appeal of geometric ornament to commentators attracted to supernaturalist metaphysics.

Introduction: Islamic geometric ornament and mysticism

Geometric decoration is one of the fundamental themes of Islamic ornament. Some of the finest and most famous works of Islamic art and architecture are decorated with geometric patterns of varying degrees of complexity, from the simple use of circular forms in coiling vegetal ornament (e.g., at the Dome of the Rock in Jerusalem) to the exquisitely intricate star patterns found on surfaces ranging from ceilings to book covers (Figure 1). It may be true that geometric ornament is not original to Islamic civilization, which adopted it from developments in the Late Roman art it inherited, but it is nevertheless undeniable that Islamic art as a whole has come to be broadly identified, not unjustifiably, with a “look” of complex geometric patterning.

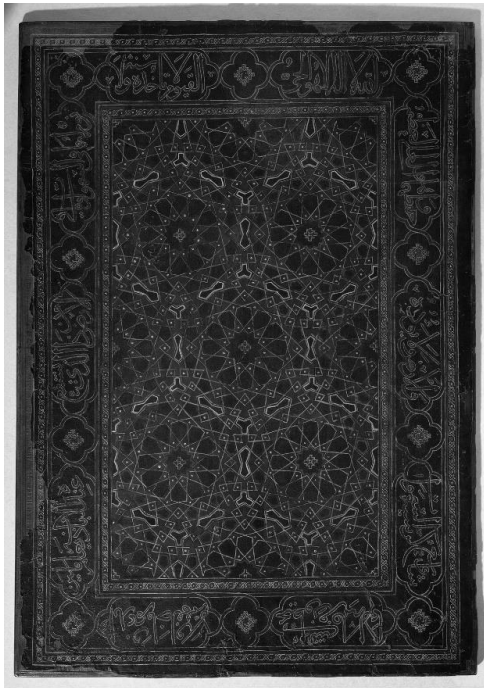


Figure 1: Leather manuscript binding, Egypt/Syria, 14th cent. (<https://artsandculture.google.com/asset/2AHTWo6AbVyLpA>). © Photo: Museum für Islamische Kunst der Staatlichen Museen zu Berlin - Preußischer Kulturbesitz; Photographer: Johannes Kramer. Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Germany License, <http://creativecommons.org/licenses/by-nc-sa/3.0/de/deed.en>)

Over the years, a number of interpretations have arisen to guide our understanding of what, if anything, the makers of these patterns saw in them or intended to communicate by making them. Early students of Islamic art tended to attribute pattern types to the inherent mentality of given ethnic categories, such as Arabic, Persian, and Turkish (for a survey of such attitudes, see Necipoğlu 1995). Later, the idea was put forth that the patterns were not just there for visual enjoyment, but had actual conceptual import as expressions of a mystical religious worldview. This interpretation became widespread in the 1970s, first with the publication of the book *The Sense of Unity: The Sufi Tradition in Persian Architecture*, which presented not just decoration but the entire Iranian architectural tradition as an expression of Sufi (i.e., mystical Islamic) beliefs in the transcendental unity of creation (Ardalan and Bakhtiar 1973). The Sufistic reading of Islamic art was also fundamental to the 1976 Festival of Islam in London, where the exhibition catalog's introduction by the celebrated Swiss Muslim traditionalist Titus Burckhardt informed readers that "There is in this geometry of pythagoran [sic] origin a harmony and a memory of the music of the spheres" (Burckhardt 1976:32). Later, the prominent Iranian philosopher Seyyed Hossain Nasr wrote a monograph in which he argued for a deep and ramified relationship between Islamic art (including geometric ornament) and Muslim spirituality (Nasr 1987). The cosmological interpretation of Islamic art as an expression of "timeless wisdom" connected to true Being continues to this day (Critchlow 2013).

In the 1990s, a more scholarly justification for the mystical interpretation of Islamic geometric ornament was provided by Gülru Necipoğlu (Necipoğlu 1995). Necipoğlu first catalogues and criticizes the various interpretations of geometric ornament (specifically the star patterns she terms "the girih mode"), including the outright mystical view, as products of an ahistorical discourse of essentialism. Then, basing her own argument on a careful analysis of medieval texts on philosophy, mathematics, and the crafts, she takes the position that Islamic geometric ornament as a historical development was indeed related to religious concepts—specifically, certain religious and philosophical doctrines being propagated from Baghdad during the so-called "Sunni Revival" of the 10th century. Islamic geometric ornament, in this view, is an expression of mystical thinking, only it occurred as a specific, traceable process in Islamic history, the product of particular intellectual interests, socio-political developments, and "culturally constructed codes of recognition" (Necipoğlu 1995:83) rather than some ineffable and timeless Muslim piety.

Although Necipoğlu's thesis is indeed more scholarly and sophisticated than those of her predecessors, it must be judged wanting as an

interpretation of Islamic geometric ornament (Allen 2004, 2016). The crux of the problem is that despite Necipoğlu's best efforts, she does not provide unambiguous textual evidence of the philosopher–craftsman encounters she claims occurred and drove the development of the so-called “girih mode.” Nor, for that matter, do Nasr, Ardalan and Bakhtiar, or any of the other proponents of the mystical interpretation of Islamic geometric ornament. No one, in fact, has ever produced a medieval document that would attest to the direct consultation of philosophers by craftsmen, let alone to the explicit communication of Neoplatonist ideals from the former to the latter in the nature of a design request, or to the interpretation by any contemporaries of a geometric pattern in terms of propositional religious content (“This means the infinity of God,” “That means the Breath of the Compassionate,” etc.); the usual tactic is to claim, without proof, that the knowledge was passed down in secretive craft guilds (e.g., Critchlow 2013:13). Although there are interesting indications of an awareness of craft practices on the part of professional mathematicians (Hogendijk 2012), this is not the same as the claim that craftsmen were consciously carrying out a program of Neoplatonist semiotics. The existence of a historical nexus between mystical philosophy and geometric decoration remains undemonstrated.

The lack of textual evidence, while problematic, is not the only flaw in the mystical interpretation of Islamic geometric ornament. In fact, a careful analysis of some of the works themselves reveals cracks in the edifice. For example, it is common to claim that Islamic geometric patterns suggest infinite expansion beyond the borders of the design, and by implication the infinity of God. The notion of infinity, however, is not a mandatory reading. Classical Islamic compositions, such as in Figure 1, are carefully arranged so that the pattern is cut off in precisely a way so as to create quarter-motifs in the corners and half-motifs on the sides (Broug 2013:48). Were such a pattern really intended to be read as an excerpt from an infinitely repeating pattern, it could have been cropped anywhere and still suggested continuity beyond the borders. Moreover, it seems equally plausible to read the quarter- and half-motifs as “sealing in” the pattern and making it a coherent symmetrical composition, rather than suggesting a window on an infinite expanse. (Given the skill required to design and execute a pattern this precisely, there may also be an element of panache on the part of the craftsman responsible.) In addition, we may also note how some patterns include a “tweak” to make them work, such as when the designer subtly bends lines at certain intersections to integrate shapes that otherwise would not fit into the same grid (Broug 2013:161). The necessity for such tweaking is difficult to reconcile with the concept of a flawless divine Unity.

The truly vitiating error in the mystical approach, though, is not evidential or analytical but methodological—namely, the rush to abstraction and the attendant neglect of perception. By this I mean the willingness to assume the transparency of human perceptual processes in the haste to get to theoretical propositions. The apparent premise underlying such haste is the idea that if there is no conceptual content, then the artworks are “just” pattern, a notion some find impossible. “It cannot be just pattern” is the implication; “there has to be some deeper meaning to these patterns, because they were made in a religious culture, or a milieu saturated with Neoplatonist concepts, or what have you; Q.E.D.” The result of this approach is a tendency to see geometric ornament as merely a stepping-off point for metaphysical speculation, with insufficient respect, even awe, for the manifest complexity of perception as human beings perform it, for the aspect(s) of perception that are invoked, manipulated, stimulated, or otherwise called into play by this kind of percept, or for the nature and significance of the perceiver’s experience of that aspect(s). The patterns are there, the idea goes, and now we can get to the interesting and serious part, which is teasing out the spiritual commentary implicit in the intersecting lines. The upshot is an implausible relegation of the flesh-and-blood makers and consumers of Islamic ornament to the status of disembodied processors of abstractions. Clearly, this is a paradigm in need of rethinking.

Perception, ecology, and cognitive efficacy

Let us, then, begin at the beginning, by repeating what initially seems like a trivial observation: The makers and consumers of Islamic geometric ornament were flesh-and-blood human beings. They lived in terrestrial nature, the world of earth and sky and trees and streams, just as we do. Living, in turn, means acting. With every bird and beast in nature, these people shared the task of pursuing survival by choosing actions aimed at gaining and keeping certain values, whether basic organismal needs like food and shelter or higher-level human values like companionship and a sense of religious certitude.

Another seemingly obvious point is that to pursue any of these actions, the medievals in question had to look around and perceive the world. Again in common with other animals, every single one of these people, qua living organism, had to gain information about his or her environment to act in pursuit of values and, ultimately, survival. The human perceptual system is our evolutionary inheritance for gaining such information.

The point I am making here is that to fully understand perception—not to mention artifacts made expressly to be perceived, such as ornament—we need to take into account all the facts of human perception as a natural phenomenon. We need to grasp the nature of perception, not just as the faculty we bring to an isolated experimental context (such as a psychological laboratory or a hypothesized engagement with “cultural codes of recognition”), but as a biological process that evolved to enable the human animal to survive in a terrestrial environment. This is known as the ecological perspective (Gibson 1979), and it is the basic methodological approach that I argue is proper to bring to pattern, indeed to aesthetics generally.

Part of understanding perception in an ecological setting, in turn, is understanding its nature as an active process (Noë 2004). Perception, in this view, is not something that happens to people—or to any perceiving being; it is something they do. Looking is not merely passive receiving; looking is action, both bodily and cognitive. Physically, we engage in a host of actions to explore our environment, from standing up and walking around to swiveling our heads to moving our eyes in involuntary saccades; cognitively, too, the brain has to work to integrate the information gleaned from our sense organs into a cohesive unity, so that we experience, not a farrago of discrete sense data, but a single, cohesive world.

Importantly, it follows from this that an essential task of cognition is the discovery of patterns. Indeed, pattern has been described as “the fundamental currency of intelligence” (Hawkins and Blakeslee 2004:63). Pattern-recognition is what enables successful prediction, whether of the next stimulus (Hohwy 2013; Clark 2016) or of the potential results of action in the world. A flux of completely disparate stimuli, a hodgepodge of random instantaneous data with no invariants, would offer no basis on which to grasp the environment, let alone initiate bodily action in and through it. Stimuli that fall into a pattern, no matter how simple or limited, mean that the organism’s consciousness can know what is coming, at least to some degree, and therefore act with some assurance of success, even if that only means taking a step or picking up a tool. Pattern and periodicity mean predictability, and predictability, in nature, means the chance for survival-oriented action. This is the rule for all living things, from beetles and snails to birds, horses, dogs, cats, and human beings.

I want to suggest that on the human level, geometric ornament offers us the opportunity for pattern recognition in its simplest and most literal form. In the course of viewing (and thus visually processing) a geometric pattern, we grasp, however subverbally, that certain shapes, e.g., stars or bowties or kite-shapes, will repeat at certain intervals and in certain places. The pattern thus provides a field of perceptual input in

which the realization of periodicity, and hence the successful prediction of how the world is going to behave (at least in this context), is simple, almost effortless—certainly more so than the process of extracting invariances from a whole complex, immersive environment. For a few moments and on a certain simple level, consciousness seems to “run on rails.” (It should be noted that the sense of success is indubitably proportionate to the difficulty of the task; a checkerboard, to take an example, exhibits clear periodicity, but is not particularly satisfying to look at, whereas a sophisticated work of Islamic geometric ornament can draw the viewer in for extended sessions of rapt visual delectation.) As is the case with any personal effort that achieves its end, the work required to perceive the world is, in such a context, met with a palpable affective payoff. This feeling of having succeeded in its fundamental task, to sum up, is rewarding to human consciousness in a uniquely subtle and profound way. The aesthetic appeal of geometric pattern comes from the sense of cognitive efficacy it affords.

Examples

To illustrate the basic idea, consider again Figure 1, the Mamluk bookbinding. The pattern in the main compartment is relatively easy to sort out. A group of 12-pointed stars and the compartments created by the extension of their lines form a series of geometric rosettes; these are surrounded by “chains” of bowtie-shapes alternating with three-winged shapes, all highlighted with pigment, which form links between rosettes on an axis parallel to the long edge of the book. There are also colored dots placed in most of the small spaces created by the intersecting lines. The composition as a whole is tightly integrated, with each part easily and logically woven into the adjacent ones; no arbitrary shapes or “tweaks” are necessary to force the pattern to cohere. As such, the composition offers the viewer the sense of predictability I am arguing for here, namely the basic awareness of repeating patterns. “This will appear again there”—this wordless prediction runs in tandem with the ongoing process of examining the binding’s surface, and even when previously unnoticed units are discerned (like the triangles that surround the three-winged motifs in the “chains” around the stars), they, too, fall into line with prediction, in accordance with the logic of the pattern. The underlying sense that consciousness is working, that it is confidently and easily predicting its environment, is the root of the unique pleasure this type of perceptual experience offers.

The same observations apply to virtually any work of Islamic geometric ornament, right up to the finest examples. Figure 2 shows the inner dome of the so-called Mausoleum of Turabeg Khanom in Kunya

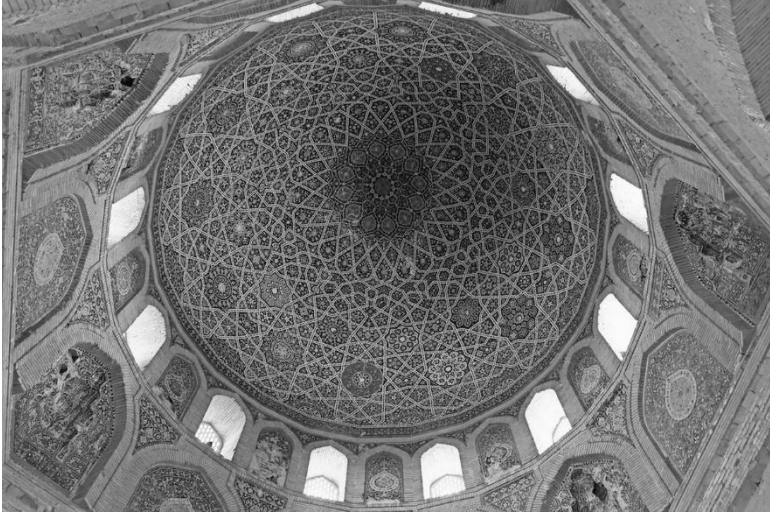


Figure 2: Inner dome of the “Mausoleum of Turabeg Khanom” in Kunya Urgench, Turkmenistan, ca. 1390 (Photo credit: John Pavelka, <https://commons.wikimedia.org/w/index.php?curid=74698218>. Published under the Creative Commons Attribution 2.0 Generic license.)

Urgench, Turkmenistan, which is thought to date to approximately 1390 (Golombek 2011).

The tilework inside the dome is truly a tour de force of geometric patterning. At the center is a curvilinear composition based on 12-pointed stars, which serves as the center for a pattern with 24 points. This in turn radiates outward, via a series of cleverly arranged intersections that create (inter alia) a kind of staggered-star motif, to integrate first with a ring of 9-pointed stars, and then with an outer ring of 10-pointed stars. The planning of such a complex pattern required a very high level of skill to execute it without any “cheats,” such as filler patterns or subtle bends at troublesome intersections (Broug 2013:192). For all of its complexity, though, the same principle applies to this pattern as to the previous—namely, that it is the discovery of predictable repetition in the network that makes the pattern a pleasure to look at and engage with, from the large-scale stars around the outer rim to the floral motifs lodged within even the smallest polygon in the network.

For a different angle on this approach to Islamic geometric ornament, see Figure 3. This is the inner dome of the thirteenth-century Karatay Medrese in Konya, Turkey.

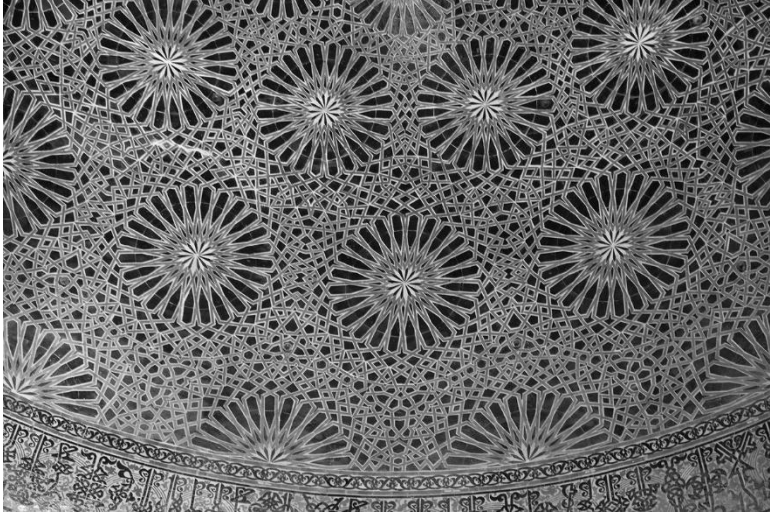


Figure 3: Detail of the inner dome of the Karatay Medrese, Konya, Turkey, 1251-2 (Photo credit: Dosseman, <https://commons.wikimedia.org/w/index.php?curid=77538355>. Published under the Creative Commons Attribution-Share Alike 4.0 International license.)

The pattern here consists of a series of 24-pointed stars in a complex mesh of intersections that arguably do not integrate well into a periodic pattern. It is true that there are no obvious errors or “crashes” in the design, meaning areas of the pattern that display clearly awkward or arbitrary shapes forced on the designer in order to get out of a tricky design situation (such as an overlarge gap or an intersection with too many angles). Yet in this pattern, the complexity has gotten out of hand; the design is overcrowded; it gives the impression not of an evenly distributed pattern of repeating units, but of a set of stars floating in a sea made up of more disparate little shapes than the eye can comfortably keep track of. The fact that the partial stars along the edge are further away from the whole stars than are the whole stars from each other is quite conspicuous and makes the mass of tiny shapes even more salient. The resulting impression is of a field in which it is much more difficult (though not impossible) for the eye to predict what shapes will recur and where. Accordingly, the pattern is less successful—less conducive to the sense of efficacy gained from successful recognition and prediction—than the previous examples.

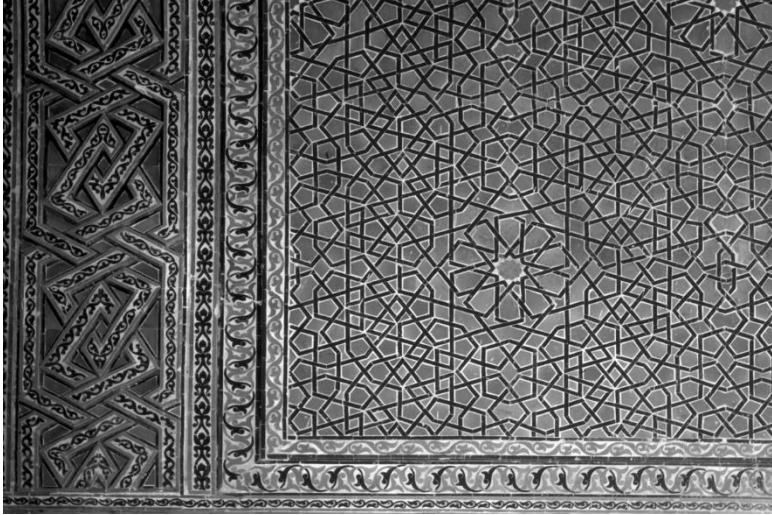


Figure 4: Detail of tilework from the interior of the Karatay Medrese (Photo credit: David Wade, <https://patterninislamicart.com/archive/main/10/turkey/tur0309>. Reproduced by permission of patterninislamicart.com.)

A similar criticism may be voiced regarding another section of tilework from the same building, seen in Figure 4. The pattern is the product of genuinely skillful work, but its virtuosity is its albatross. We may note that the network was sufficiently overcomplex to require the insertion of 10-pointed star motifs, like the one slightly below and right of center in the illustration, to serve as “visual anchors” (Broug 2013:159), without which the pattern would fail to resolve into clearly repeating, and thus predictable, motifs. It is true that there are repeating motifs in the design, notably pentagons and diamonds of various sizes, but the very intricacy of the design has the effect of muting them and forcing the viewer to work too hard to see them. They do not “pop,” like visual anchors should, and the enjoyment of successful prediction is thus blunted. This may be one reason designs like this are not common in Islamic ornament. (For another example of a pattern that may have been seen as too clever by half, see Figure 5.)

This brief series of examples gives some indication of the point about pattern perception and appreciation that I want to raise here. Note that the first two examples feature distinct and regularly occurring motifs that easily attract the eye; such “visual anchors” are basic features of countless examples of geometric ornament across the Islamic world. The



Figure 5: Gonbad-e Kabud, Marageh, Iran, 1196-97 (Photo credit: Davod Mojtahedi/public domain, <https://commons.wikimedia.org/wiki/File:Gonbadkabod9.jpg>)

patterns from Karatay Medrese and Gonbad-e Kabod, however, while perhaps sophisticated in mathematical terms, do not generate such motifs (or have had them artificially inserted, as in Figure 4), and I suggest that this failure to comport with the aspect of geometric ornament that gives pleasure, namely the enjoyment of cognitive efficacy felt in successful perceptual prediction, is a possible reason (along with sheer difficulty of design) for the rarity of such patterns in Islamic geometric ornament.

Conclusion: Mysticism and geometry

I have argued that the mystical interpretation of geometric ornament is fundamentally flawed and that we should look for the appeal of these patterns in the nature of our perceptual apparatus and the experience of wielding it a certain way. However, the observation that pattern affords a pleasurable sense of cognitive efficacy may itself suggest an explanation for the popularity of geometric ornament with those who are attracted to supernaturalist metaphysics. Brought to bear on a geometric design, the mind can fulfill its essential function of pattern recognition with relative ease—something that cannot be said for its interaction with

the world of people, objects, and nature generally. The sense of “frictionless” function gained from focus on an abstract ornamental pattern probably suggests to a certain mindset that here is contact with a realm of pure consciousness or spirit, a realm free of the vexing unpredictability of recalcitrant, mind-resistant matter. This feeling is what Plato and his successors, human beings one and all, were trying to rationalize in constructing their metaphysical systems. As pointed out above, there is no evidence that the medieval Islamic craftsmen who created these designs had any such thing in mind when they worked, but those who come to the patterns with cosmology on their mind seem to link the ornament to it quickly and easily. The use of geometry does not make one a mystic, but mystics are drawn to geometry, and the framework I have tried to sketch out in this brief essay, one that roots the appeal of geometry in terms of the human mind and its ecology, may make some earthly sense of that curious fact.

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Analysis of Attitudes Toward the Use of Essential Oils Among Utah Valley University Students

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Abstract

Essential oils are immensely popular in the state of Utah. Proponents of essential oils suggest that they can be used to improve an array of emotional and physical ailments. Whether they are an effective home remedy or not, the perceptions of the therapeutic efficacy of essential oils vary greatly. Research on the perceptions of essential oils among college-educated adults in the state of Utah is lacking. Obtaining higher education in the sciences may influence skepticism of essential oils as a complementary and alternative medicine. The purpose of this study was to understand how Utah Valley University students' education influences their attitudes toward essential oils as complementary and alternative medicines. The information gathered about the students' views on essential oils was compared with their respective educational disciplines and sex. The results showed that science major students were more likely to be skeptical of essential oils as a valid form of medical treatment than were students majoring in a non-science degree ($P < 0.000003$).

Introduction

An essential oil is typically defined as a concentrated oil extract of botanical origin. These oils are a well-known natural product with suggested uses that span from treating illnesses, to providing pleasant aromas, and even to things like cleaning. These oils have been used for religious and medicinal purposes for thousands of years and have biologically active components that have been shown to have antimicrobial activity, antioxidant, and antiviral activity (Peters, 2016). In recent years, the essential oil industry has expanded significantly as consumers' interest in natural alternatives to traditional drugs has grown and the use of essential oils has broadened to things such as cosmetics and aromatherapy (Hunter, 2009). The U.S. Food and Drug Administration (FDA) and Drug Supplement Health and Education Act (DSHEA) of 1994 have classified them as cosmetic or food products because of the time and expense required to classify them as drugs (DSHEA, 1994; FDA, 2017). The potential therapeutic benefits of essential oils have not been widely studied. The widespread popularity of self-care natural products such as essential oils has caused the therapeutic claims and distribution of essential oils to be more closely scrutinized by the FDA (Manion & Widder, 2017).

Utah is home to many companies within the botanical supplement or nutraceutical market and often these products are sold through multi-level marketing companies. Two of the largest essential oil companies are headquartered in Utah—doTerra and Young Living. In 2014, the FDA sent a severe warning letter to doTerra and Young Living, requesting these companies to change the claims about the abilities of their oils to treat cancer, brain injury, autism, Alzheimer disease, and attention deficit/hyperactivity disorder. In this letter, the FDA cited several of their social media posts, such as, “oils that could help prevent your contracting the Ebola virus” (Monroe, 2017). Consumers are not always educated in scientific inquiry and able to read and interpret the scientific literature. Although essential oils certainly have a place in complementary and alternative medicine (CAM), this dissemination of misleading and unreliable information has contributed to the climate of skepticism surrounding essential oils in the state of Utah.

The National Center for Health Statistics has released several key surveys of interest involving the topics of the use of CAM. In 2004, a nationwide survey revealed that 36% of people over the age of 18 use some form of CAM (National Institutes of Health, 2004). In another study, researchers found that those with higher education were more likely to support the use CAM; however, medical students were found to be the most critical toward CAM usage compared with students of other

professions (Harris & Rees, 2000). This trend was also supported by other comprehensive research indicating similar results (Frass et al., 2012).

The prevalence of essential oil use in Utah could be due to the presence of numerous essential oil companies or it may be a cultural phenomenon. In any case, research on attitudes of essential oils in Utah is lacking, but the use of essential oils to treat ailments remains fairly common in the state. They are becoming an increasingly important factor for clinicians to consider when it comes to educating their patients about CAM and evaluating patient care (Manion & Widder, 2017). Analyzing the perceptions of the use of essential oils as a medical treatment among university students may provide insight into the fields of education that predispose people to be supportive or not of essential oils, if education plays a role at all. The implications of such an analysis could be as far-reaching for developing a good approach to educate the public on the use of essential oils or even educating clinicians about how to discuss essential oils with patients. This study analyzes the attitudes toward the use of essential oils among Utah Valley University (UVU) students.

Materials and Methods

This study was conducted at UVU in Orem, Utah. UVU is the largest public university in the state, with approximately 39,931 students enrolled (UVU News, 2018). A convenience sample was gathered by conducting structured interviews using an 11-question survey (see Appendix). Convenience sampling is a nonrandom sampling method in which “individuals who fit the criteria of a study are identified in any way possible” (Emerson, 2015). Students were approached in the hallways of various locations on the UVU campus and asked if they would participate in a brief survey. Each student was given the opportunity to read and sign a letter of informed consent before participating in this research study. The participants’ responses to the survey questions were recorded using Qualtrics survey software from the researchers’ mobile devices. The research was approved by the Institutional Review Board, tracking number #183.

The goal of the interview questions was to ascertain the participants’ views on essential oils as an effective form of alternative medicine. The survey also contained questions that would provide information about the students’ sex and area of study or major; determination of a correlation between the type of major and the support of essential oils was a major focus in this study. The researchers wanted to evaluate whether students majoring in a science were more likely to be skeptical of the therapeutic benefits of essential oils than were students

majoring in a non-science. Therefore, the convenience sample was based on a knowledge of the types of classes and majors that normally occupy certain buildings on the UVU campus, thus making it more likely to survey a student majoring in a science or a non-science, depending on the building chosen. This method allowed the interviewers to obtain an even distribution of surveys from students in science and non-science majors. The following UVU buildings were sites where surveys were conducted: Liberal Arts, Clarke Classroom Building, Science Building, Pope Science, Gunther Technology, Computer Sciences, and Woodbury Business.

Following the completion of the surveys, the data were collected and sorted. The participants were sorted by their major, which was the final question of the survey. The majors were used to sort responses into two strata: science majors and non-science majors. Science majors were defined as those majoring in Chemistry, Earth Science, Biology, Exercise Science, and Physics. All others were considered non-science majors for the purposes of this study. The reason for this distinction is the requirement in these majors to take Principles of Chemistry II (CHEM 1210) and College Biology (BIOL 1610), which the researchers believe is a branching point in the scientific education of students. The participants were also sorted based on the year in their education (freshman, sophomore, etc.) and by their sex for further statistical analysis. Using “R” statistical computing software, an analysis of variance (ANOVA) test was used to assess the differences between the perceived medicinal value of essential oils and the type of major, as well as the year in school. Finally, a t-test was conducted to assess whether males or females were more likely to recommend the use of essential oils to a friend or family member.

Results and Discussion

Each survey took no longer than 5 minutes. The survey was completed by 98 students.

The focal point of comparison between science and non-science majors and year of school as related to their opinions of essential oil effectiveness resided predominantly in question #4 from the survey. A value was given based on question #4. Points were given, 1–6, 1 being the most negative attitude value, and 6 being the most positive attitude value. As shown in Figure 1, the results indicate that science majors share a more skeptical view of the medicinal value of essential oils than non-science majors.

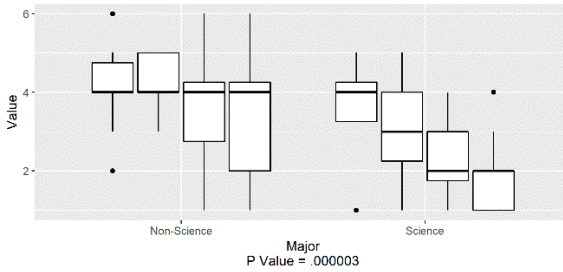


Figure 1: Boxplot of perceived value of essential oils by freshman, sophomores, juniors, and seniors (in that order), depending on their major. Value ranged from 1, most negative, to 6, most positive.

Interestingly, non-science majors gave essential oils a higher value than science majors, with statistically significant differences, similar to what has been reported by Harris and Rees (2000). It appears that seniors and juniors give less value to the use of essential oils than freshmen and sophomores (Figure 2), indicating that the higher the level of schooling, the lower their appreciation for the use of essential oils as CAM. This finding agrees with some findings that the more advanced students and medical students show lower appreciation for the use of CAM in modern medicine (Harris & Rees, 2000; Furnham and McGill, 2004; Radi et al., 2018). Although the students surveyed in our study were not medical students, many students planning to attend medical school in the future opt to major in the biological sciences, which would fall under the category of science major. This might explain the similarity between the views of science major students in this study and that of medical students reported in other studies. A study in Germany showed that women and people with more education used CAM more often than men and people with lower amount of education (Härtel and Volger, 2004). There are few studies published of the acceptance of CAM by the general population and the analysis of the attitude of the general population toward the use of essential oils. Some studies that reflect the apprehension of medical students or doctors toward the use of CAM for patients suggest that it is simply lack of training and exposure. After 231 health care practitioners were educated on 5 commonly used essential oils, indications for use in patient populations and safety and contraindications for use, 74% of participants agreed or strongly agreed with the statement, “Because of the [training] module, I feel more comfortable discussing the use of essential oils with my patients.” Boesl and Saarinen (2016) reported that 67% of participants planned to ask their patients about integrative health and essential oils, and most planned to change their practices or seek

more information on the subject. Essential oils are starting to see more applications in a dental office setting as well. The *RDH* magazine for registered dental hygienists is starting to publish research and care guidelines about the use of essential oils. For example, in an education module, clove oil is recommended as an alternative method for treating pain from dry socket. Tea tree oil, peppermint oil, and thyme oil are noted as oral antiseptic options to supplement other oral hygiene practices (Pierce, 2018).

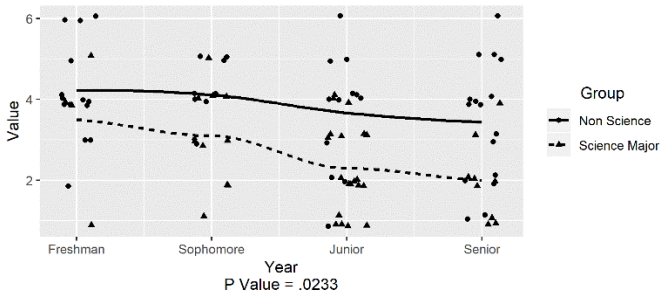


Figure 2: Comparison of the perceived value of essential oils related to the year of schooling (Science vs Non-science majors). P value for major = 0.000003. P value for year = 0.0233. Value ranged from 1, most negative, to 6, most positive.

Reports indicate that males are statistically more likely to pursue a career involved in the sciences (Sax et al., 1996; Eccles and Wang, 2016), it was hypothesized that the disparity between the types of majors and views on essential oils shown in Figures 1 and 2 was perhaps due to differences in sex. However, when the results were analyzed, it was found that among those surveyed in this study, the number of males in a science major compared with females in a science major was not different enough to be statistically significant.

The differences in perception of essential oils were not limited to the type of major alone; the results suggest the presence of sex differences in the use of essential oils (Figure 3). Analysis of the likelihood of recommending essential oils to friends or family members (question 7) indicated that males were extremely unlikely or moderately unlikely to recommend their use compared with females (this difference was statistically significant). These results are in accordance with previous research (Barnes et al., 2009, Laiyemo et al., 2015, Alwhaibi and Sambamoorthi, 2016). If an informant reported they were likely to recommend the use of essential oils, this was interpreted as a positive perception of the efficacy of essential oils as a medical treatment. If a

participant reported they were unlikely to recommend use, then the response was interpreted as a negative view of the efficacy of essential oils.

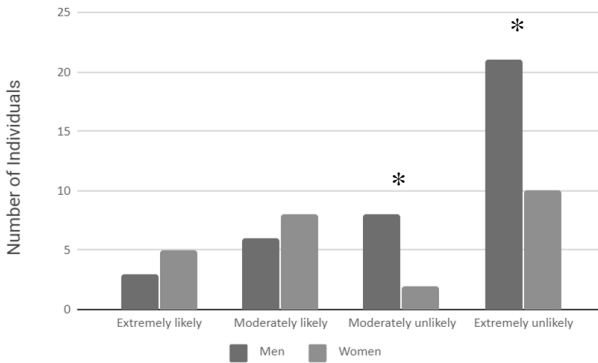


Figure 3: Number of participants who would recommend essential oils to friends or family members (question 7). P value=0.02. * indicates statistical significance.

Essential oils have a place in CAM because there is evidence that they have antioxidant and antimicrobial activities, as well as having other health benefits (Mith et al., 2014; da Silva et al., 2017). Among UVU students, essential oils would be used for a wide variety of ailments as shown by the results displayed in Figure 4. Ailments that are minor in severity such as a headache or cold were reported to be treated using essential oils more often than a severe ailment such as cancer. Science majors most often reported that they would not use essential oils to treat any ailment. While both types of majors would use essential oils for each of the ailments listed in the question, non-science majors were much more likely to use essential oils to treat an ailment in every case. The results suggest that there may be widespread anecdotal information on the veracity of the therapeutic effects of essential oils. The skepticism among the students pursuing an education in science may suggest that these students are the type of person to question such anecdotal information or that various classes in biological or chemical sciences influence their views on complementary and alternative medicines such as essential oils. More effort needs to be made to provide the public with reliable sources of information about the medicinal uses of essential oils. There still was a large percentage, however, that had not considered using essential oils for any of the ailments indicated.

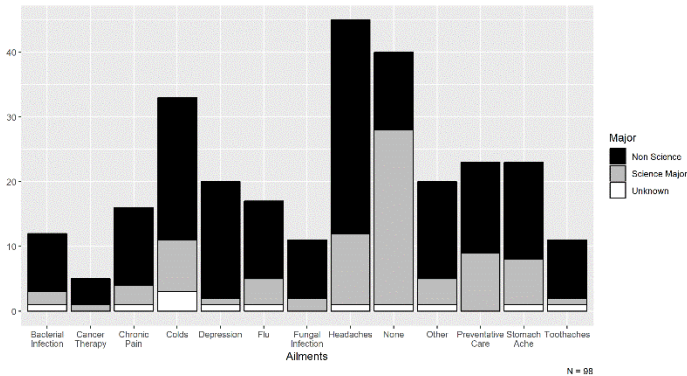


Figure 4: Potential uses of essential oils by informants (question 3).

This study yielded interesting and potentially significant results but indicates that more thorough, large-scale research needs to be done in this area because the obvious limitations of this study are recognized. There is a possibility of sampling error due to the method of convenience sampling implemented in this study that inhibits the ability to generalize the results. The sample size needs to be increased in future studies to more fully represent the populations we examined. This study serves as a starting point for future essential oil research among university students.

Conclusion

Science majors had a general disposition to be more skeptical than non-science majors when using essential oils to treat ailments, especially serious illnesses. The therapeutic value of essential oils was more often challenged by science majors. Non-science majors were generally more open to using essential oils as a complementary and alternative medicine for a variety of illnesses. Those further along in their college education, regardless of major, tended to be more wary of using essential oils as a medical treatment. In addition, there was a statistically significant difference between women and men, with the former showing a more positive outlook on the use of essential oils.

Acknowledgments

We thank those students of Utah Valley University who willingly helped by taking our survey for this data collection.

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Appendix

Questions of the research instrument used to evaluate the attitudes toward the use of essential oils by Utah Valley University students

1. Have you ever used or considered using essential oils?
 - a. Yes
 - b. No
2. What would you use essential oils for? Check all that apply:
 - a. Nothing
 - b. Fragrance
 - c. Aromatherapy/relaxation
 - d. Cleaning
 - e. Medicinal treatment
 - f. Cooking
 - g. Other
3. Which ailments would you treat with essential oils? Check all that apply:
 - a. Preventative care
 - b. Depression
 - c. Headaches
 - d. Colds
 - e. Flu
 - f. Fungal infection
 - g. Bacterial infection

- h. Stomach ache
 - i. Cancer therapy
 - j. Toothaches
 - k. Chronic pain
 - l. Other
 - m. None
4. How would you describe the medicinal value of essential oils?
- a. Could be harmful (Negative value)
 - b. No negative or positive effect (No value)
 - c. Any benefit is barely noticeable (Minimal value)
 - d. May be beneficial as a home remedy (Potential value)
 - e. Increases effectiveness of traditional medicine (Moderate value)
 - f. Could be used as an alternative to traditional medicine (Exceptional value)
5. Imagine you have had fatigue, moderate fever (~100°F), and aches for three days. What would be your response in regards to seeking medical care?
- a. I wouldn't go to a doctor for a mild fever
 - b. I'll make an appointment tomorrow if symptoms persist
 - c. I'm calling to make an appointment today
 - d. I already have an appointment
6. When you have a mild cold and flu-like symptoms, what do you use to treat yourself at home?
- a. No treatment, my body will take care of it
 - b. Take over the counter medication such as ibuprofen and NyQuil
 - c. Home remedies such as cough drops, hot water bottle, and fluids
 - d. Seek out prescribed medication
7. How likely are you to recommend the use of essential oils to a friend or family member?
- a. Extremely likely
 - b. Moderately likely
 - c. Indifferent
 - d. Moderately unlikely
 - e. Extremely unlikely

8. How far along in your education are you?
 - a. Freshman
 - b. Sophomore
 - c. Junior
 - d. Senior
9. Have you taken any of these college-level class in biology, chemistry, or physics? Check all that apply:
 - a. BIOL 1610
 - b. b. BIOL Other
 - c. CHEM 1210
 - d. d. CHEM Other
10. What is your gender?
 - a. Male
 - b. Female
 - c. Other
11. What is your major?

Analysis of Four Plant Organellar tRNA Genes: Further Evidence of Gene Transfer

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Abstract

*Horizontal gene transfer (HGT) to plant organelles occurs as interorganismal transfer or as promiscuous transfer. This study looks at HGT involving four tRNA genes in plant/algal mitochondrial, chloroplast, cyanobacterial, α -proteobacterial, and chlamydial genomes. A total of 64 trnN-GUU, 56 trnS-GCU, 50 trnD-GUC, and 41 trnQ-UUG sequences previously deposited in GenBank were selected and analyzed. This includes data corresponding to trnN-GUU (11 sequences) and trnS-GCU (12 sequences) genes that were previously assessed in the context of HGT. None of the trnD-GUC and trnQ-UUG sequences have been evaluated previously. Phylogenetic results for trnN-GUU and trnS-GCU agreed with an earlier hypothesis of HGT between chlamydial and mitochondrial genomes. New examples of possible HGT from a chlamydial genome are presented for trnN-GUU: 1) *Dryopteris blanfordii* (chloroplast), 2) *Psilotum nudum* (mitochondrial), and 3) putative pseudogene repeats for *Gingko biloba**

(mitochondrial). No evidence of HGT from chlamydial genomes was found for *trnD-GUC* and *trnQ-UUG*. Promiscuous transfer was not found for *trnS-GCU* or *trnD-GUC*. For *trnS-GCU* and *trnQ-UUG*, α -proteobacterial and cyanobacterial/chloroplast genes grouped together, suggestive of HGT. For all genes, distinct mitochondrial copies of *Amborella trichopoda* sequences affiliated with diverse taxa, indicative of interorganismal gene transfer. This study furnishes additional evidence of gene transfer involving tRNA genes to organellar genomes.

Introduction

Horizontal gene transfer (HGT) is the transmission of genetic material between genomes not involving lineal descent (Keeling and Palmer 2008) and is increasingly considered an important evolutionary mechanism (Bock 2010, Sulaiman *et al.* 2019). This paper follows Huang and Gogarten (2008) in treating promiscuous transfer (intracellular gene transfer) as a form of HGT and looks at both interorganismal gene transfer and promiscuous transfer with respect to tRNA genes in the plant chloroplast and mitochondrial genomes.

Promiscuous transfer between plant mitochondrial and chloroplast genomes or between these organelles and the nuclear genome has been recognized for some time (Wintz *et al.* 1988, Hao and Palmer 2009, Smith 2011). Ellis (1982) first used the term “promiscuous” to describe Stern and Lonsdale’s (1982) discovery of a 12-kb sequence in the maize mitochondrial genome that was homologous to a portion of the chloroplast inverted repeat. Promiscuous transfer between the three plant intracellular genomes does not appear to occur at equal rates (Smith 2014). It is well known that plant nuclear genomes contain many sequences of chloroplast and mitochondrial origin (Yoshida *et al.* 2014). Likewise, mitochondrial genomes have acquired sequences from both the nucleus and the chloroplast (Notsu *et al.* 2002, Knoop 2004, Wang *et al.* 2007). Thus, intracellular transfers to the nucleus or the mitochondrion are generally viewed as being relatively common (Straub *et al.* 2013). In contrast, genetic transfers to the chloroplast were thought, until relatively recently, not to happen at all (Smith 2014). Although still considered rare, transmission from the mitochondrion to the chloroplast, at least, has been now documented for a very small number of plant species (Goremykin *et al.* 2009, Ku *et al.* 2013, Ma *et al.* 2015). Studies have indicated that intracellular transfers not only have occurred anciently but appear to be ongoing (Timmis *et al.* 2004). Although “bulk DNA,” “cDNA intermediates,” and other mechanisms have been proposed as

explanations, they remain strongly debated (Adams *et al.* 2000, Henze and Martin 2001, Timmis *et al.* 2004, Straub *et al.* 2013, Smith 2014).

Interorganismal horizontal transfer of genetic material into plant organelles has also been documented, including transmission from different plant taxa and from bacterial sources (Cho *et al.* 1998, Woloszynska *et al.* 2004, Davis *et al.* 2005, Richardson and Palmer 2007, Moustafa *et al.* 2008, Rice *et al.* 2013). Mechanisms proposed for this kind of transfer to organellar genomes include parasitic plant–host plant relationships (Mower *et al.* 2004, Davis and Wurdack 2004), viral or bacterial vectors (Won and Renner 2003), and fungal–plant associations (Davis *et al.* 2005), although, as Won and Renner (2003) point out, these are mostly conjecture. Interorganismal mitochondrion-to-mitochondrion transfer appears to be the most prevalent form of HGT observed between plants (Richardson and Palmer 2007).

Among the groups of organellar genes that have been assessed with regard to HGT is the tRNA gene family (e.g., Marechal *et al.* 1987, Oda *et al.* 1992, Guo *et al.* 2017). As is widely known, tRNAs play an important role in protein synthesis by transferring amino acids to the ribosome during translation, although much remains unknown about the evolution of these genes as a group (Fujishima and Kanai 2014). Nevertheless, they are the subject of considerable research as to their role in the evolution of organellar genomes. For example, because many tRNA genes, or a combination of them with other sequences, are frequently found at or near the endpoints of reordered blocks of chloroplast genes, it is thought that they could sometimes be involved in recombination and rearrangements in the chloroplast genome (Hiratsuka *et al.* 1989, Haberer *et al.* 2008, Gao *et al.* 2010). This suggests that the location of some tRNA sequences may be associated with chloroplast structural evolution.

The number of tRNA genes present in plant organellar genomes is often variable both in terms of the number of kinds of genes present and in the number of copies of each gene present. Most plant chloroplasts encode ~30 different tRNA species in terms of anticodons, which is generally considered sufficient for protein synthesis (Legen *et al.* 2007). However, the number of tRNA genes with respect to genetic loci will be usually somewhat higher (Michaud *et al.* 2011). For instance, Park *et al.* (2018) reported 30 tRNAs for *Lamprocapnos spectabilis*, but the number of loci shown on their chloroplast gene map is 42 tRNA genes, not counting 2 pseudogene copies for *trnI*-CAU. The main reason for such a difference in number between chloroplast tRNA species and tRNA genes is the basic circular plant chloroplast structure, which consists of a large single-copy (LSC) region and a small single-copy (SSC) region separated by two inverted repeats (IRs) (Daniell *et al.* 2016). Unless there has been a duplication, there will be one copy of a gene that is in either the

LSC or the SSC region, but two copies in the IR. Also adding to the variability in gene number between different taxa are chloroplast structural differences, such as variation in the precise location of the IR boundaries between two distinct taxa, which may cause a gene to be located in one of the single-copy regions of one species but be in the IR of the other species. For example, many plants in the rosid group have just one *trnH*-GUG gene in the LSC region, but this gene is associated with the IR for many plants in the rosid family Elaeagnaceae (Choi *et al.* 2015). Also, in addition to the two copies of each gene in the IR, it is possible to have duplicate copies of a gene in one of the single-copy regions. For example, there are duplicate copies of the *trnR*-CCG gene in the LSC region of *Welwitschia mirabilis* (McCoy *et al.* 2008).

For most plants, the number of mitochondrial tRNA genes varies from 17 to 29 (Michaud *et al.* 2011, Salinas-Giegé *et al.* 2015). It should be noted that since this range of values may include duplicated genes, the actual number of tRNA species will be somewhat fewer. For example, the mitochondrial genome of *Gossypium raimondii* has 25 tRNA genes in terms of genetic loci, but the *trnD*-GUC gene has 3 copies, whereas the genes for *trnM*-CAU-cp, *trnM*-CAU-2, and *trnW*-CCA each have 2 copies (Bi *et al.* 2016). This means that the number of actual mitochondrial tRNA species by anticodon is 20. Such low numbers are usually not enough for protein synthesis to occur, and many plant mitochondrial genomes do not have any tRNA genes for alanine, arginine, leucine, threonine, or valine (Michaud *et al.* 2011). An extreme example of tRNA gene deficiency is the mitochondrial genome of *Selaginella moellendorffii*, which appears to completely lack tRNA genes (Hecht *et al.* 2011). In those cases so far examined, import of nuclear-encoded tRNAs is known to provide the missing tRNAs (Duchêne *et al.* 2009).

Like other mitochondrial genes, the tRNA genes that are found in plant mitochondria generally fall into two major groups of sequences: 1) native mitochondrial, or genes present in the organelle by lineal descent, and 2) chloroplast-like (most at >90% similarity to known chloroplast sequences) and acquired by promiscuous transfer (Marechal *et al.* 1987, Joyce and Gray 1989, Oda *et al.* 1992). It should be noted, however, that the mitochondrial genomes of a few plant taxa consist entirely of native sequences and do not have any of chloroplast origin, e.g., *Marchantia polymorpha* (Oda *et al.* 1992).

An exceptionally small number of mitochondrial genes appear to have been acquired by HGT from bacteria, including some tRNA genes (Salinas-Giegé *et al.* 2015, Guo *et al.* 2017). For example, Knie *et al.*

(2014) reported HGT between chlamydial and plant mitochondrial genomes for 4 tRNA genes and found chlamydial affinities for certain lycophyte, fern, and gymnosperm taxa.

Finally, plant-to-plant transfer is also known to account for the presence of some non-native mitochondrial genes. An extreme example of this is the 3.9-Mb mitochondrial genome of *Amborella trichopoda*, whose protein, but not tRNA, genes have been phylogenetically evaluated previously in the context of HGT (Bergthorsson *et al.* 2004, Rice *et al.* 2013). GenBank annotations of *Amborella* mitochondrial sequences indicate not only the presence of native and chloroplast tRNA sequences, but also that many genes, including those for tRNAs, were acquired by interorganismal transfer from green algae, mosses, and other angiosperms.

The present study attempts to further evaluate the relationships of four groups of tRNA genes appearing in plant organellar and bacterial genomes with respect to HGT and uses a phylogenetic approach. Two groups, *trnN*-GUU and *trnS*-GCU, were previously evaluated (see Materials and Methods), but the present study considerably expands the analyses for these genes both in number and/or in taxonomic diversity of sequences. The study also looks at two additional groups of genes, *trnD*-GUC and *trnQ*-UUG, which, so far as could be determined, have not previously been evaluated in this manner.

Materials and Methods

Taxon selection and sequence downloading

Sequences representing *trnN*-GUU, *trnS*-GCU, *trnD*-GUC, and *trnQ*-UUG genes were selected as described below. All sequences were previously deposited in GenBank. Organellar sequences were selected to represent the range of systematic variation among plants (bryophytes, lycophytes, ferns, gymnosperms, and angiosperms) and included algal sequences as well. Because endosymbiotic theory postulates that mitochondria share an ancestor with extant α -proteobacteria (Yang *et al.* 1985, Gray *et al.* 1999, Thrash *et al.* 2011) and chloroplasts are thought to have descended from a common cyanobacterial ancestor (Douglas and Raven 2003), representative sequences from these two groups of bacteria were selected also. As HGT of tRNA genes from chlamydial genomes into some plant mitochondrial genomes has been observed previously, gene sequences from this group of bacteria were selected as well.

Two of the tRNA genes assessed here, *trnN*-GUU and *trnS*-GCU, were previously evaluated by Knie *et al.* (2014). For *trnN*-GUU, 11 sequences corresponding with respect to taxonomic and genomic origin to

those previously examined were included in the present study. These were *Parachlamydia acanthamoebae* (chlamydial), *Simkania negevensis* (chlamydial), *Treubia lacunosa* (mitochondrial), *Pleurozia purpurea* (mitochondrial), *Marchantia polymorpha* (mitochondrial), *Nitella hyalina* (mitochondrial), *Oryza sativa* (chloroplast and mitochondrial), *Asplenium nidus* (mitochondrial), *Cycas taitungensis* (mitochondrial), and *Huperzia squarrosa* (mitochondrial). An additional 53 *trnN*-GUU sequences were added to this dataset based on BLAST searches (Altschul *et al.* 1990, Zhang *et al.* 2000, <https://blast.ncbi.nlm.nih.gov/Blast.cgi>). For *trnS*-GCU, there were 12 sequences corresponding to those previously examined that also were evaluated here. These were *C. taitungensis* (mitochondrial), *Psilotum nudum* (chloroplast), *N. hyalina* (mitochondrial), *Chara vulgaris* (mitochondrial and chloroplast), *P. purpurea* (mitochondrial), *T. lacunosa* (mitochondrial), *Equisetum arvense* (chloroplast), *O. sativa* (chloroplast), *H. squarrosa* (mitochondrial), *Isoetes engelmannii* (mitochondrial), and *P. acanthamoebae* (chlamydial). BLAST searches identified 44 more *trnS*-GCU sequences that were subsequently included.

To find other potential tRNA genes of interest, organellar genomes for plant taxa already included were closely screened. This process identified *trnD*-GUC and *trnQ*-UUG as possible candidates. As with the first two genes, BLAST searches were performed to identify corresponding chlamydial, proteobacterial, cyanobacterial, chloroplast, and plant/algal mitochondrial sequences. The 50 *trnD*-GUC and 41 *trnQ*-UUG sequences assessed here were detected in this manner.

All sequences used in this study are listed in Appendix 1. Note that none of these sequences were generated by the present author but are the work of other researchers. Not all sequences were used in all analyses.

Sequence alignment and tRNA verification

The sequences were carefully aligned as there were varying degrees of length variation in the 4 sets of downloaded sequences due to the presence of indels. Additionally, some sequences contained introns, which were removed prior to the alignment and any subsequent analyses. Consideration was also given to the selection of an alignment program as each program uses different criteria and algorithms to align a set of nucleotide or protein sequences (Pais *et al.* 2014), which means that the same set of sequences could be aligned in slightly different ways depending which program is used. Resulting alignments should be scrutinized to ensure that corresponding homologous regions between sequences are properly aligned. Selection of sequence alignment programs may not necessarily always be a one-size-fits-all approach, and several studies

have used one program to align a particular group of nucleotide or protein sequences but a second program for a different set of sequences (e.g., Hoogewijs *et al.* 2012, Higashi *et al.* 2017). The MUSCLE sequence alignment program (Edgar 2004a,b) was initially used to align all set of sequences. Inspection of the resulting alignments between homologous regions appeared to be appropriate for the *trnS*-GCU, *trnD*-GUC, and *trnQ*-UUG datasets. However, this did not appear to be the case for the *trnN*-GUU sequences. These were reprocessed using the MAFFT program (Kato *et al.* 2002), which appeared to give a better alignment for these sequences. Both MUSCLE and MAFFT are available at the European Bioinformatics Institute website (<https://www.ebi.ac.uk/Tools/msa/>). All alignments were saved in FASTA format (Lipman and Pearson 1985, Pearson and Lipman 1988).

Sometimes it was necessary to confirm that sequences were tRNAs using the tRNAscan-SE 2.0 server (Lowe and Chan 2016, <http://lowelab.ucsc.edu/tRNAscan-SE/>). In a few cases, verification was necessary after the removal of introns to help ensure that the edited sequence would form a proper secondary structure. This was also done in a very small number of instances where BLAST analysis found unannotated nucleotide regions that appeared to be homologous with previously recognized tRNA genes. Aside from this, secondary structures were not otherwise evaluated.

Phylogenetic analysis

Phylogenetic analyses have been used previously to detect and evaluate HGT (Logsdon and Faguy 1999, Stanhope *et al.* 2001, Richards *et al.* 2011). They were performed here to identify affiliations of sequences in terms of genomic origin. Systematic relationships between taxa included here were not directly evaluated. The FASTA alignments for each set of tRNA sequences were evaluated phylogenetically by the MEGA7 program (Kumar *et al.* 2016) using Maximum Likelihood (ML). Prior to the ML analysis of each set of tRNA sequences, the “Find Best DNA/Protein Models (ML)” option was used in MEGA7 to determine the most appropriate nucleotide substitution model. MEGA7 generates Bayesian information criterion (BIC) and Akaike information criterion-corrected (AICc) values in evaluating substitution models. Although BIC and AICc generally agree on the best model for the dataset, this is not always the case. Where the two criteria appeared to disagree, the best-scoring models for each were phylogenetically analyzed, and the resulting tree topologies, resolution, and overall branch support were compared. For each set of sequences, the substitution models used were: 1) *trnN*-GUU, Kimura 2-parameter model with a gamma distribution

($G=0.6374$) and invariant sites ($I=38.1412\%$); 2) trnS-GCU, general time reversible with gamma distribution ($G=1.1205$) and invariant sites ($I=21.2199\%$); 3) trnD-GUC; Tamura 3-parameter model with invariant sites ($I=41.3986\%$); and 4) trnQ-UUG, Kimura 2-parameter model with a gamma distribution ($G=0.5134$) and invariant sites ($I=45.6970\%$). ML was performed using nearest-neighbor-interchange, and bootstrapping (BS) was performed to determine branch support. The initial trees were generated from a pairwise distance matrix using neighbor-join and BioNJ algorithms with the maximum composite likelihood approach as implemented in MEGA7. In the resulting phylogenies, mitochondrial sequences are indicated with “mt” following the taxon name, whereas “cp” is used to indicate chloroplast (or cyanelle, for 1 taxon). Numbering was also used where there was more than one organellar variant.

Results

Consistent with previous studies, BLAST searches confirmed that for some taxa there were both multiple copies and sometimes different versions (i.e., same anticodon but with an otherwise different nucleotide sequence) of genes within the same organellar genome. The primary example of this was in *A. trichopoda* for all 4 sets of tRNA genes examined here, but also included a few other taxa as well. For each set of tRNA gene sequences evaluated, the CCA aminoacyl acceptor end, when present, was found in α -proteobacterial sequences only. In a general sense, none of the tRNA gene groups appeared to be useful for systematic/phylogenetic analysis of plant taxa on any large or deep scale.

trnN-GUU analysis

Among the 53 additional sequences included on the basis of BLAST searches, 3 sequences had strong similarities with sequences of chlamydial origin and are reported here for the first time for *Psilotum nudum*, *Dryopteris blanfordii*, and *Ginkgo biloba*. First, there were 2 distinct copies of trnN-GUU found in the mitochondrial genome of the fern *P. nudum*. Not surprisingly, one of these had strong chloroplast sequence similarities consistent with previous studies. However, BLAST found a second sequence showing up to 95% identity based on BLAST searches with mitochondrial sequences previously shown to be of possible chlamydial origin. Secondly, 2 very dissimilar trnN-GUU sequences were found in the chloroplast genome of *D. blanfordii*, one of which had over 97% identity with chlamydial like mitochondrial sequences. Finally, duplicated sequences in the mitochondrial genome of *G. biloba* had 89% identity with the potentially chlamydial derived sequence in the *Cycas taitungensis* mitochondrial genome mentioned earlier.

Analyses using tRNAscan-SE 2.0 identified the *P. nudum* and *D. blanfordii* sequences as tRNA gene sequences. The potentially chlamydiaally derived *P. nudum* sequence was assigned a much lower score (37.0) by tRNAscan-SE 2.0 than the other *P. nudum* sequence (79.2). In contrast, the chlamydial version for *D. blanfordii* had a score (74.6) that was somewhat more comparable to that of its native gene version (81.6). The 2 distinct mitochondrial sequences of *trnN*-GUU for *P. nudum* were aligned with its chloroplast gene (Fig. 1). Although not identical to the chloroplast sequence, the second mitochondrial version shared several features with it that indicated a chloroplast origin. This included a 4-bp deletion not found in the mitochondrial copy of chlamydial origin. Likewise, 2 different chloroplast versions were observed in the *D. blanfordii* inverted repeat. These were aligned with the chloroplast copy of its congener *D. filix-mas* (Fig. 2). The chlamydial version differed from both the other *D. blanfordii* sequence and with the sequence for *D. filix-mas*, which were identical. The *G. biloba* sequence has been duplicated, possibly triplicated. The sequence for the 2 identical copies was used in the analysis. This version was aligned with the other sequences of chlamydial origin (Fig. 3) and was distinguished from these sequences by a deletion of 8 nucleotides, which includes 2 anticodon nucleotide positions. This obviously precluded its identification as a functional tRNA. Except for this deletion, it was otherwise identical to the sequence for *C. tai-tungensis*, the only other gymnosperm included in the chlamydial group. Otherwise, this sequence and the other vascular plant organellar sequences were united by the presence of a thymine at a single nucleotide indel position, which was absent in any of the included chlamydial bacteria. A third *G. biloba* copy, which differs by 7 nucleotide positions (4 substitutions and 3 gaps) is also present but was not used in the analysis.

anticodon

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Psilotum_nudum_mt1  TCCGATTAGCCTTCTCAGTCGGTGGAGCAGTGGACTGTTAATCCATAGTTCGGAAGTTCGAGTCTTGGATCCGAGA1
Psilotum_nudum_mt2  TCCCCAGTAG----CTCAG-TGGTAGAGCGGTCGGCTGTTAACCGATCGGTCGTAGGTTCAAGTCTCACTCAGGAG2
Psilotum_nudum_cp   TCCTCGGTAG----CTCAG-CGGTAGAGCAGTCGGCTGTTAACCGATGGTTCGTAGGTTCAAAATCCTATCCGAGGAG3

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Figure 1. Alignment of *trnN*-GUU gene sequences for *P. nudum*.

¹Mitochondrial sequence of hypothesized chlamydial origin; ²mitochondrial sequence of chloroplast origin; ³native chloroplast sequence.

anticodon

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Dryopteris_blanfordii_cp1  TTCGGATTAGCTCAGTCGGTAGAGCAGTGGACTGTTAATCCATGGGTGCAAGTTCGAGTCTTGATCCGGAG1
Dryopteris_blanfordii_cp2  TCCTCGGTAGCTCAG-CGGTAGAGCGGTCGGCTGTTAACCGATTGGTCGTAGGTTCAATCTACCCGGGGAG2
Dryopteris_filix-mas_cp   TCCTCGGTAGCTCAG-CGGTAGAGCGGTCGGCTGTTAACCGATTGGTCGTAGGTTCAATCTACCCGGGGAG3

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Figure 2. Alignment of *trnN*-GUU gene sequences for *Dryopteris* sequences.

¹Chloroplast sequence of hypothesized chlamydial origin for *D. blanfordii*; ²native chloroplast sequence for *D. blanfordii*; ³native chloroplast sequence for *D. filix-mas*.

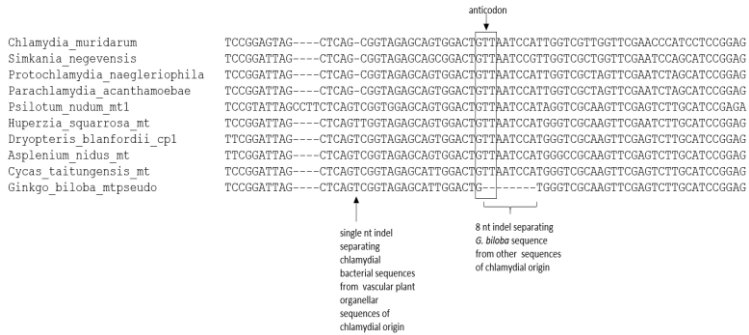


Figure 3. Alignment of *trnN*-GUU chlamydial sequences. The upper 4 sequences are from bacteria in the phylum Chlamydiae. Below them are 6 sequences of hypothesized chlamydial origin found in organellar genomes of vascular plants.

The aligned *trnN*-GUU gene sequences were 72 to 77 bp in length. All chlamydial bacterial sequences were 72 bp, as were the cyanobacterial, native chloroplast, and mitochondrial sequences of chloroplast origin. Most DNA sequences of native mitochondrial origin (algal and bryophyte only) were 73 bp in length. However, 3 mitochondrial sequences had different lengths. Two of these were *A. trichopoda* variants, designated “*Amborella trichopoda* mt2” and “*Amborella trichopoda* mt3” in this study, which were 72 and 74 bp, respectively. The *Chlorella* mitochondrial sequence was also 72 bp. All 3 of these grouped together in the *trnN*-GUU phylogenetic analysis (Fig. 4). The α -proteobacterial sequences were 75 bp. Except for the CCA aminoacyl acceptor end (α -proteobacterial only), all length variation was due to indels in the region corresponding to the D-arm of the functional tRNA secondary structure.

Phylogenetic analysis of the *trnN*-GUU sequences indicated 4 distinct assemblages of sequences: 1) chlamydial, 2) mitochondrial, 3) α -proteobacterial, and 4) cyanobacterial/chloroplast-like (Fig. 4). The chlamydial group included vascular plant sequences found in either the mitochondrion or the chloroplast, which was suggestive of HGT. This also included 1 of the 2 mitochondrial sequences for *P. nudum*, a mitochondrial sequence for *G. biloba*, and 1 of the 2 chloroplast sequences for *D. blanfordii*. Additional interorganismal gene transfer was indicated by 2 other *A. trichopoda* sequences that grouped with a green alga. Lastly, phylogenetic analysis did group chloroplast sequences of eusporangiate ferns together, although with weak BS support (BS=54%). In addition to the second *Psilotum* sequence, the mitochondrial sequences of several taxa appeared to have a chloroplast

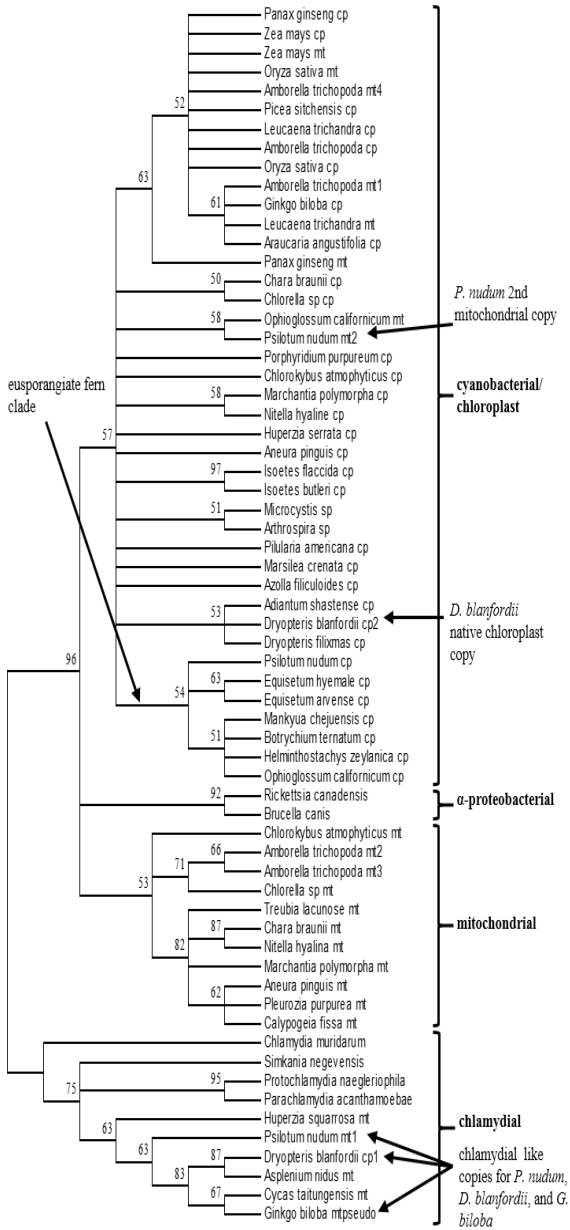


Figure 4. ML tree for *trnN-GUU*. Numbers above branches are BS values.

origin. Including 2 different variants of *A. trichopoda*, these were the angiosperms *Zea mays*, *Oryza sativa*, *Leucaena trichandra*, and *Panax ginseng*, as well as the fern *Ophioglossum californicum* (which clustered with the *Psilotum* sequence), indicating promiscuous transfer.

trnS-GCU analysis

For *trnS*-GCU gene sequences, length variation was mostly confined to the region corresponding to the secondary structural variable arm, although for 1 *Diplostephium* mitochondrial variant (“*Diplostephium hartwegii* mt1”), there was small length variation also in the T-arm. Cyanobacterial DNA sequences were 90–93 bp, whereas chloroplast sequences ranged from 88 to 90 bp. Chlamydial bacterial sequences were 87–88 bp in length, whereas putative chlamydial variants in vascular plants were 86–87bp. Native mitochondrial sequences varied from 85 to 92 bp, and α -proteobacterial sequences were in the 91–92 bp range. Although it was included in the phylogenetic analysis for *trnS*-GCU, the secondary structure could not be determined for a 96-bp *A. trichopoda* mitochondrial variant (“*Amborella trichopoda* mt 2”) because of an 8-adenine repeat between the variable arm and the T-arms. One *A. trichopoda* mitochondrial sequence (“*Amborella trichopoda* mt1”) was in a clade that otherwise consisted of red and green algae, indicative of possible HGT.

The MP analysis produced 3 sets of sequences: 1) those of chlamydial origin, 2) a group comprised of both α -proteobacterial and cyanobacterial/chloroplast sequences, also suggestive of HGT, and 3) mitochondrial sequences (Fig. 5). Within the mitochondrial sequences, a strongly supported (BS=92%) liverwort/hornwort clade was observed. Additionally, chloroplast sequences grouped together all gymnosperms, although with weak support (BS=57%). The alga *Cyanophora paradoxa* and the angiosperm *D. hartwegii* both had 2 different mitochondrial versions of this gene, although, because of their similarity, it appeared that these were due to possible duplication events and not HGT.

trnD-GUC analysis

In contrast to *trnN*-GUU and *trnS*-GCU, there were not any vascular plant mitochondrial or chloroplast sequences that were observed to have a chlamydial origin. Except for several of the numerous *A. trichopoda* mitochondrial sequences that appeared in the cyanobacterial/chloroplast group, all mitochondrial sequences appeared to be native in origin. Most *trnD*-GUC DNA sequences were 74 bp in length. However, the published sequence for the green alga *Chlorella* was 75 bp because of a single thymine insertion in the area corresponding

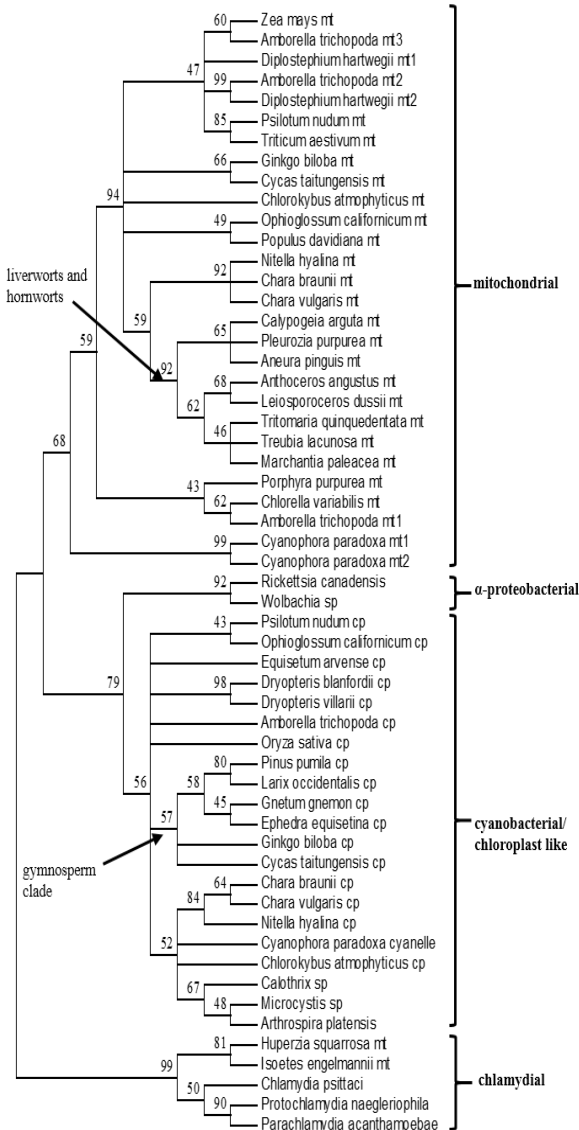


Figure 5. ML tree for *trnS-GCU*. Numbers above branches are BS values.

to the secondary structure D-loop. The α -proteobacterial gene sequences were 77 bp because they included the CCA aminoacyl acceptor sequence on the 3' end.

Three groups of sequences were obtained: 1) strictly chlamydial bacterial, 2) α -proteobacterial/mitochondrial, and 3) cyanobacterial/chloroplast (Fig. 6). An ophioglossoid fern clade (BS=71%) appeared in the chloroplast sequences. Also recovered was a general angiosperm clade (BS=79%), which included the sole chloroplast sequence and 2 different mitochondrial sequences from *A. trichopoda*. *A. trichopoda* sequences formed several affiliations that indicated possible gene transfer.

trnQ-UUG analysis

The majority of *trnQ*-UUG sequences were 72 bp in length. However, one of the *A. trichopoda* mitochondrial variants was 71 bp while the orchid *Erycina pusilla* had a mitochondrial sequence of 73 bp. Because of the presence of the CCA aminoacyl acceptor terminus, all α -proteobacterial sequences were 75 bp.

Like *trnS*-GCU, sequences were placed phylogenetically into one of three groups: 1) those of chlamydial origin, 2) a group comprised of both α -proteobacterial and cyanobacterial/chloroplast sequences, suggestive of HGT, and 3) mitochondrial sequences (Fig. 7). As with *trnD*-GUC, there was not any evidence of HGT from chlamydial bacteria into the organellar genomes for any of the included sequences. Along with 1 mitochondrial variant of *A. trichopoda*, the mitochondrial sequence of *E. pusilla* grouped with the cyanobacterial/chloroplast sequences, suggesting possible promiscuous transfer. As with the other 3 tRNA genes, other *A. trichopoda* sequences were associated with a diversity of taxa, which may be due to interorganismal gene transfer.

Discussion

HGT to or between plant organelles has been reported for several genes (Bergthorsson *et al.* 2004, Timmis *et al.* 2004, Rice *et al.* 2013). Although this paper focused on *trnN*-GUU, *trnS*-GCU, *trnD*-GUC, and *trnQ*-UUG, other tRNA genes have been studied in light of HGT, e.g., *trnL*-GAG and *trnS*-GGA (Knie *et al.* 2014). There was some very limited phylogenetic usefulness for some of these genes with regard to certain groups of taxa. For example, chloroplast *trnN*-GUU sequences grouped together eusporangiate ferns (Figure 4), a mitochondrial liverwort/hornwort and chloroplast gymnosperm clades were obtained for *trnS*-GCU (Figure 5), and *trnD*-GUC chloroplast sequences included both angiosperm and ophioglossoid fern assemblages. For the most part,

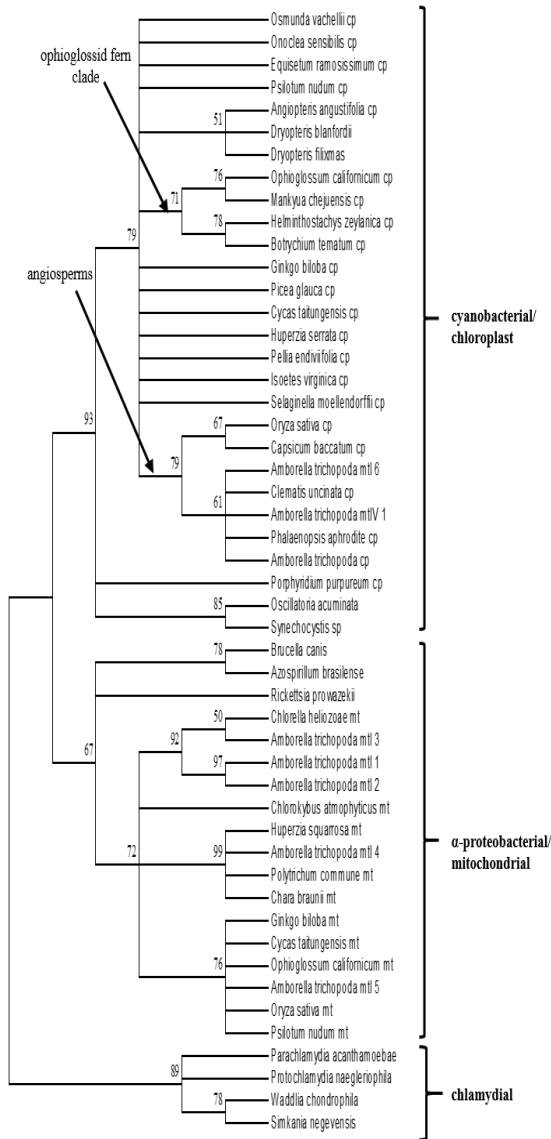


Figure 6. ML tree for *trnD-GUC*. Numbers above branches are BS values.

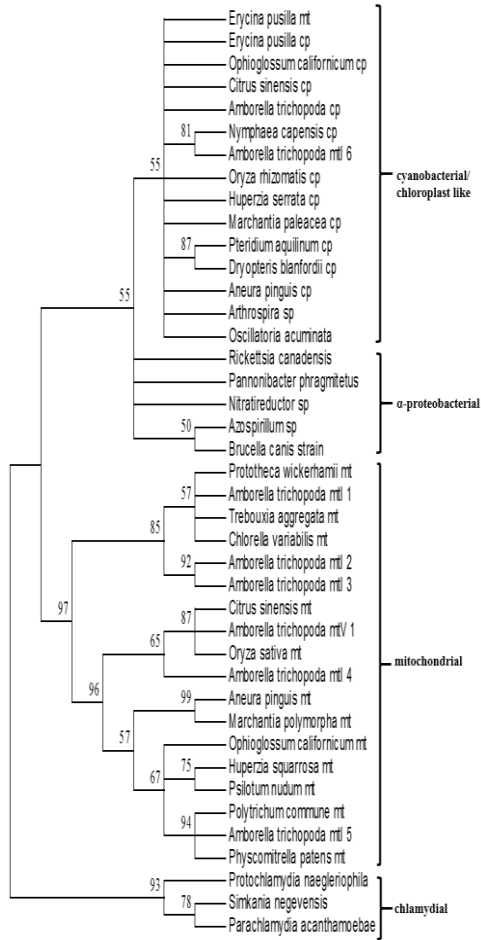


Figure 7. ML tree for *trnQ*-UUG. Numbers above branches are BS values.

however, accepted taxonomic relationships were not generally resolved, and the phylogenies presented here are interpreted not as species trees, but as gene trees.

Based on the phylogenetic results obtained, both interorganismal and promiscuous gene transfer were observed in this study for *trnN*-GUU (Figure 4). These findings are consistent with Knie *et al.* (2014) as to interorganismal transfer from chlamydial genomes to plant organellar genomes and previously unreported examples of this are presented here, including an example of transfer into a chloroplast genome (see below).

Also observed for several vascular plants was promiscuous transfer from chloroplast genomes to mitochondrial genomes, comparable with what has been reported for other genes (Notsu *et al.* 2002, Knoop 2004). Also included in this analysis were *trnN*-GUU sequences from the highly complex *Amborella trichopoda* mitochondrial genome, which showed a variety of diverse phylogenetic relationships with other plant taxa and organellar genomes (Figure 4), including green algae (mitochondrial), as well with gymnosperms and angiosperms (chloroplast). Previous studies have shown that *A. trichopoda* obtained multiple variants of numerous genes from a diverse group of algal and plant sources through HGT (Bergthorsson *et al.* 2004, Rice *et al.* 2013). While these studies have phylogenetically analyzed the acquisition by gene transfer of protein genes for *A. trichopoda*, they note that tRNA sequences were not analyzed phylogenetically, although other analyses allowed identification and annotation of tRNA sequence data with respect to origin (see Bergthorsson *et al.* 2004, Rice *et al.* 2013).

Reported here for the first time, to the best of the author's knowledge, is the presence of a *trnN*-GUU sequence of chlamydial origin in the mitochondrion of *Psilotum nudum*, in addition to a second mitochondrial variant of chloroplast origin whose affinities in this study were closest with that of *O. californicum* (Figure 4). Complete mitochondrial sequences for *P. nudum* were deposited in GenBank by Guo *et al.* (2017) as accession numbers KX171638 (*P. nudum* chromosome 1) and KX171639 (*P. nudum* chromosome 2). The chloroplast-like copy is listed in the annotations for accession KX171639. While Guo *et al.* (2017) do mention a chlamydial-like copy of *trnR*-UCG in the mitochondria of both *O. californicum* and *P. nudum*, there is not any mention of a chlamydial derived *trnN*-GUU gene for *P. nudum*. The chlamydial version, though not appearing in the annotations, is located on KX171638 at positions 343191–343267. It differs from all other chlamydial copies of *trnN*-GUU by a 4-bp insertion (Figure 1).

Also reported here for the first time is the presence of a *trnN*-GUU gene of possible chlamydial origin in the *Dryopteris blanfordii* chloroplast genome. In addition to the apparently chlamydial *trnN*-GUU in its chloroplast genome, the fern *D. blanfordii* has a second, but different, *trnN*-GUU gene of native chloroplast origin, which is identical to the one found in the chloroplast of a congener species *D. filix-mas*. *D. filix-mas* does not have the chlamydial like *trnN*-GUU sequence. It was not ascertained here whether this was due to an earlier HGT event into *Dryopteris* with a subsequent loss in most other species in the genus or if this is a more recent gene transfer affecting only this particular species. As already noted, transfer into chloroplast genomes is usually considered an

unusual event compared with the mitochondrion, so this observation appears to be relatively unique at any rate. The chloroplast genome map of Logacheva *et al.* (2017) indicated that what is here treated as the native version is located in the inverted repeat. The chlamydial-like sequence was found by the present study to be also in the inverted repeat and is located in the *rrn16* intron. However, Logacheva *et al.* (2017) do not identify this specific *trnN*-GUU version and only show it on their map as an unidentified tRNA (i.e., as “trn”).

Finally, a duplicated sequence appearing in the mitochondrial genome of the gymnosperm *Ginkgo biloba*, which had considerable similarity to *Cycas taitungensis*, another gymnosperm, was also seen in this study. Native mitochondrial *trnN*-GUU genes are not present in vascular plants, and those mitochondrial sequences that are present appear in only certain lineages (e.g., lycophytes, monilophytes, gymnosperms) and appear to be acquired from chlamydial bacteria at very early stage in plant evolution (Knie *et al.* 2014). If this hypothesis is accepted, then the close similarity of the *C. taitungensis* and *G. biloba* sequences is likely due to their acquisition through HGT by a common evolutionary ancestor. Although the precise systematic nature of the relationship differs between studies, phylogenetic analyses have indicated generally that *G. biloba* has a close affiliation with cycads (such as *C. taitungensis*) and that these are the two most basal gymnosperm lineages (Chaw *et al.* 1997, Bowe *et al.* 2000, Wu *et al.* 2013). Except for the 8-bp deletion, the *G. biloba* sequence was found to be identical with that for *C. taitungensis*, which, as already noted, is also suspected to be of chlamydial origin. In *G. biloba*, this sequence has been duplicated, possibly triplicated. There are 2 identical copies, plus a third that differs by 7 nucleotide positions (4 substitutions and 3 gap positions). As far as could be determined, no such gene was identified in the mitochondrial genome of *Welwitschia mirabilis* (Guo *et al.* 2016), another gymnosperm.

As with *trnN*-GUU, the phylogenetic results for *trnS*-GCU (Figure 5) were consistent with the hypothesis of HGT from chlamydial bacteria to certain plant mitochondrial genomes (Knie *et al.* 2014). Also, there was not any evidence of promiscuous transfer in this set of sequences. One of the more interesting observations was that for both *trnS*-GCU and *trnQ*-UUG, the α -proteobacteria sequences joined with the cyanobacterial/chloroplast set, while the mitochondrial and the chlamydial each formed separate groups. It can only be a matter of speculation here as to the reasons for these discrepancies. It could be argued that the α -proteobacteria-cyanobacterial/chloroplast relationship simply reflects some sort common bacterial relationship, but, if so, why were the mitochondrial sequences so definitely excluded? On the other hand, HGT has been

invoked as a possible explanation of certain cases of gene similarity between cyanobacteria and certain proteobacterial taxa (Encinas *et al.* 2014), so a similar explanation could be employed here. Likewise, Atkinson and Baldauf's (2011) study on the evolutionary origins of elongation factor G proteins invoked HGT to explain their observation that chloroplasts have the α -proteobacterial form of the protein.

The few mitochondrial *trnS*-GCU sequences for *A. trichopoda* were mostly angiosperm in affiliation, and one of these may be of native origin. However, one sequence appeared in a clade that included a red (*Porphyra purpurea*) and a green (*Chlorella variabilis*) alga, indicating interorganismal transfer from an algal source. As with the *trnS*-GCU sequences for other taxa, there were no mitochondrial sequences for *A. trichopoda* that grouped with the chloroplast sequences.

For *trnD*-GUC (Figure 6), interorganismal transfer was observed only for some of the *A. trichopoda* mitochondrial sequences. One of this taxon's sequences appeared in a vascular plant mitochondrial group that included ferns, gymnosperms, and other angiosperms, so it is possible that this may be a native sequence. Suggestive of HGT, however, are 3 distinct *A. trichopoda* mitochondrial variants that grouped with a green alga (*Chlorella heliozoae*) mitochondrial sequence, as well as another sequence that appeared in a mitochondrial clade that included a lycophyte (*Huperzia squarrosa*), a moss (*Polytrichum commune*), and another green alga (*Chara braunii*). Additionally, 2 more dissimilar *A. trichopoda* variants appear within a polytomous angiosperm chloroplast relationship. In this last case, although the *A. trichopoda* chloroplast *trnD*-GUC sequence is also present, it is difficult to determine whether this represents interorganismal or intracellular transfer, as all sequences in this grouping are very similar to each other.

Except for the orchid *Erycina pusila* and perhaps a single *A. trichopoda* sequence, the phylogenetic results for *trnQ*-UUG (Figure 7) did not otherwise indicate any promiscuous transfer of chloroplast sequences into the mitochondrion. However, possible interorganismal gene transfer appears in distinct phylogenetic relationships within the mitochondrial group of sequences for different *A. trichopoda* mitochondrial variants. For example, 3 sequences appear in a clade that also included green algal sequences (*Chlorella variabilis*, *Prototheca wickerhamii*, *Trebouxia aggregata*). At the same time, 2 other different sequences appear in an angiosperm assemblage, but it is possible that one of these may be a native mitochondrial sequence for *A. trichopoda*. Finally, another *A. trichopoda* sequence shows strong genetic affiliations with 2 moss (*Physcomitrella patens*, *Polytrichum commune*) mitochondrial sequences. As with *trnS*-GCU, α -proteobacterial sequences were phylogenetically affiliated, not with mitochondrial sequences, but with the cyanobacterial/chloroplast.

As previously noted, similar relationships for either chloroplasts or cyanobacteria with α -proteobacterial have been observed elsewhere and were explained as being due to HGT (Atkinson and Baldauf 2011, Encinas *et al.* 2014).

Although this does not appear to have any HGT connections, the only sequences in this study that had the CCA aminoacyl acceptor at the 3' terminus were α -proteobacterial. In some organisms (e.g., various proteobacteria), the CCA aminoacyl acceptor end is genomically encoded and generated during transcription but is enzymatically added in other organisms as a post-transcriptional modification (Hou 2010). Although mitochondria have an α -proteobacterial ancestor, the native mitochondrial sequences examined in this study lacked this feature.

Although this and other studies (Logsdon and Faguy 1999, Stanhope *et al.* 2001, Richards *et al.* 2011) utilized phylogenetic analyses to identify potential HGT in organellar genomes, there are other reasons to consider HGT in explaining the presence of certain genes, especially when there are two or more very distinct versions of a gene. For example, divergence between paralogous (resulting from a duplication event) gene copies in the mitochondrion is known to occur (Perrotta *et al.* 2002), but this is viewed as occurring infrequently (Bergthorsson *et al.* 2004). In fact, mitochondrial paralogs are often found to be very similar, if not identical. For instance, Kubo *et al.* (2000) identified 3 nondivergent copies of a 6222-bp repeat unit in the sugar beet mitochondrion and inferred that there are mechanisms in mitochondrial genomes that tend to inhibit divergence between paralogs. In fact, most divergent mitochondrial copies are considered not as paralogs, but as xenologous (present due to HGT) versions, which suggests that HGT is the main, if not sole, way in which most plant mitochondrial genomes acquire different versions of a gene (Bergthorsson *et al.* 2004).

The evolution of plant organellar genomes is complex and involves a number of considerations. Of these, the endosymbiotic origin of both the mitochondrion (Yang *et al.* 1985) and the chloroplast (Douglas and Raven 2003) is perhaps the most widely known. However, endosymbiosis, while explaining much, is only part of the answer. Plant mitochondria are considered to have very high rates of structural rearrangement but generally low rates of sequence mutation (Palmer and Herbon 1988). However, mutation rates are variable, and some can be relatively high (Sloan *et al.* 2012). Furthermore, there is evidence, at least for some groups of taxa, that the mitochondria can remain relatively unchanged for a considerably long period only to diverge quickly through a surge in rearrangements, as well as through other mechanisms such as deletions (Wynn and Christensen 2019). Even for chloroplast genomes, whose size

and basic structure tend to be highly conserved among land plants, structural rearrangements have been found (e.g., Asaf *et al.* 2018, Liu *et al.* 2018). HGT adds to this organellar complexity by introducing genetic material in a nonlinear manner and, in some cases, significantly altering the genomic organization of the organelle (Rice *et al.* 2013). From the standpoint of plant systematics, this can confound the selection of organellar genes for phylogenetic studies, which already can be a complicated process. The possible presence of xenologs acquired from unrelated organisms by HGT would require careful screening of organellar genes for use in evolutionary studies of plant taxa. Such genes would share little homology with native organellar genes, and their inclusion in genetic and evolutionary studies would certainly confound systematic relationships. By focusing on tRNA genes, this paper has provided additional evidence that HGT is an important evolutionary mechanism and needs to be properly considered when evaluating genetic relationships. Relationships between genes in organellar genomes may not always conform to the expected relationships arising from endosymbiotic origins because of gene transfer. Attention should be given to possible HGT, which may complicate the clarification of phylogenetic relationships of different taxa by conflating genes of different evolutionary origins.

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Appendix 1

Sequences used in this study are listed alphabetically by taxon and show GenBank accession numbers. Not all sequences were used in all analyses. For eukaryotic taxa: cp=chloroplast or cyanelle, mt=mitochondrion. In some cases, sequences for some taxa were identified to genus only without any species identification. In keeping with taxonomic practice, “sp.” appears after the genus name. Please note that this is also how the taxonomic information appears for these sequences in GenBank.

Adiantum shastense: NC_037478 (cp); *Amborella trichopoda*: AJ506156 (cp), KF754799 (mt), KF754800 (mt), KF754802 (mt), KF754803 (mt); *Aneura pinguis*: KY702720 (cp), KY702723 (mt); *Angiopteris angustifolia*: KP099647 (cp); *Anthoceros angustus*: NC_037476 (mt); *Araucaria angustifolia*: NC_039155 (cp); *Arthrospira* sp.: CP028914; *Arthrospira platensis*: CP013008; *Asplenium nidus*: AM600641 (mt); *Azolla filiculoides*: MF177094 (cp); *Azospirillum brasiliense*: CP022262; *Azospirillum* sp.: CP029829; *Botrychium ternatum*: KM817789 (cp); *Brucella canis*: CP027643; *Calothrix* sp.: AP018254; *Calypogeia arguta*: MF401630 (mt); *Calypogeia fissa*: MF401632 (mt); *Capsicum baccatum*: NC_039695 (cp) *Chara braunii*: AP018555 (cp), AP018556 (mt); *Chara vulgaris*: AY267353 (mt), DQ229107 (cp); *Chlamydia muridarum*: CP027217; *Chlamydia psittaci*: CP033059; *Chlorella* sp.: KY629617 (cp), KY629618 (mt); *Chlorella heliozoae*: KY629615 (mt); *Chlorella variabilis*: KM252919 (mt); *Chlorokybus at-mophyticus*: DQ422812 (cp), EF463011 (mt); *Citrus sinensis*: DQ864733 (cp), NC_037463 (mt); *Clematis uncinata*: NC_039846 (cp); *Cyanophora paradoxa*: HQ849544 (mt), U30821 (cp); *Cycas taitungensis*: AP009339 (cp), AP009381 (mt); *Diplostephium hartwegii*:

KX063855 (mt); *Dryopteris blanfordii*: LT827127 (cp); *Dryopteris filix-mas*: LT618774 (cp); *Dryopteris villarii*: LT905144 (cp); *Ephedra equisetina* cp: AP010819 (cp); *Equisetum arvense*: JN968380 (cp); *Equisetum hyemale*: KC117177 (cp); *Equisetum ramosissimum*: HQ658109 (cp); *Erycina pusilla*: JF746994 (cp), KJ501973 (mt); *Ginkgo biloba*: KM672373 (mt), MG922664(cp); *Gnetum gnemon*: KR476377 (cp); *Helminthostachys zeylanica*: KM817788 (cp); *Huperzia serrata*: KY609860 (cp); *Huperzia squarrosa*: JQ002659 (mt); *Isoetes butleri*: NC_038071 (cp); *Isoetes engelmannii*: FJ390841 (mt); *Isoetes flaccida*: MG668893 (cp); *Isoetes virginica*: MG792143 (cp); *Larix occidentalis* cp: NC_039583 (cp); *Leiosporoceros dussii*: NC_039751 (mt); *Leucaena trichandra*: KT428297 (cp), NC_039738 (mt); *Mankyua chejuensis*: JF343520 (cp); *Marchantia paleacea*: M68929 (mt), X04465 (cp); *Marchantia polymorpha*: MH635409 (cp), MK202951 (mt); *Marsilea crenata*: KC536646 (cp); *Microcystis* sp.: CP020664; *Nitella hyalina*: JF810595 (mt), KX306884 (cp); *Nitratireductor* sp.: CP029208; *Nymphaea capensis*: NC_040167 (cp); *Onoclea sensibilis*: KY427354 (cp); *Ophioglossum californicum*: KC117178 (cp), KX171637 (mt); *Oryza rhizomatis* KX085497 (cp); *Oryza sativa*: CP018170 (cp), KY486275 (mt); *Oscillatoria acuminata*: CP003607; *Osmunda vachellii*: HQ658105 (cp); *Panax ginseng*: KF735063 (mt), MH049735 (cp); *Pannonibacter phragmitetus*: CP032312; *Parachlamydia acanthamoebae*: FR872580; *Pellia endiviifolia*: JX827163 (cp); *Phalaenopsis aphrodite*: AY916449 (cp); *Physcomitrella patens*: KY126309 (mt); *Picea glauca*: MK174379 (cp); *Picea sitchensis*: LT727890 (cp); *Pilularia americana*: KY863504 (cp); *Pinus pumila* cp: NC_041108 (cp); *Pleurozia purpurea*: FJ999996 (mt); *Polytrichum commune*: MG214794 (mt); *Populus davidiana*: KY216145 (mt); *Porphyra purpurea*: AF114794 (mt); *Porphyridium purpureum*: MF401423 (cp); *Protochlamydia naegleriophila*: LN879502; *Prototheca wickerhamii*: U02970 (mt); *Psilotum nudum*: AP004638 (cp), KX171638 (mt), KX171639 (mt); *Pteridium aquilinum*: HM535629 (cp); *Rickettsia canadensis*: CP003304; *Rickettsia prowazekii*: LN794217; *Selaginella moellendorffii*: MG272484 (cp); *Simkania negevensis*: FR872582; *Synechocystis* sp.: CP028094; *Trebouxia aggregata*: EU123944 (mt); *Treubia lacunosa*: JF973315 (mt); *Triticum aestivum*: GU985444 (mt); *Tritomaria quinqueidentata*: MG640570 (mt); *Waddlia chondrophila*: CP001928; *Wolbachia* sp.: HG810405; *Zea mays*: DQ490951 (mt), KR873422 (cp).

Comparative Job Satisfaction and its Determinants in the U.S., Western Europe, and Nordic Countries

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Abstract

The vast cross-disciplinary literature exploring worker attitudes and workplace conditions has linked worker experiences to many individual, organizational, and social outcomes, yet this research has largely failed to shed light on why cross-national differences in worker satisfaction and engagement and their determinants persist over time. Cross-cultural researchers suggest that these differences are due to cultural differences in each country; however, this approach has largely neglected to show that countries with similar cultural orientations still experience significant differences and related challenges. Thus, the question remains, what are the causes of these differences and what are their long-term impacts of sustainable economic development and labor prosperity? Moreover, much research has been conducted that shows either the general improvement or decline in the quality of work, but few studies have looked at such changes in work quality cross-nationally,

from the perspective of the workers. This research uses attitudinal data from the International Social Survey Program 2015 Work Orientations module, cultural variables from the Global Leadership and Organizational Behavior Effectiveness project, to examine and explore the cultural factors impacting the comparative nature of work and job satisfaction in the U.S., Western Europe, and Nordic countries.

Introduction

For decades, job satisfaction has continued to generate interest across disciplines, from sociology (Hodson, 1985) to economics (Hamermesh, 2001), management sciences (Hunt & Saul, 1975), and public administration (Wright & Kim, 2004). The interest in job satisfaction, as much for researchers as for practitioners, is due to several reasons. Satisfied workers are more productive (Appelbaum & Kamal, 2000), deliver higher quality of work (Tietjen & Myers, 1998), and improve a firm's competitiveness and success (Garrido et al., 2005). Conversely, unsatisfied workers are more frequently late for work, absent from work, and motivated to leave the firm (Hodson, 1985).

Additionally, literature across academic disciplines indicates that the nature of work has changed dramatically in recent years in response to economic shifts and an increasingly global economy (see Westover, 2008a, 2008b, 2010a, 2010b, 2012a, 2012b, 2012c, 2013a, 2013b; Westover & Taylor, 2010; Taylor & Westover, 2011; Westover et al., 2013). However, there is still relatively little known about the how, why, when, and what behind the comparative shifts of the overall quality of work and job satisfaction.

We use the International Social Survey Program Work Orientations data from 2015 and data from the Global Leadership and Organizational Behavior Effectiveness (GLOBE) Project to explore (1) the general differences in workplace conditions and employee attitudes across the U.S., Western Europe, and Nordic countries, and (2) the cultural causes for the cross-national differences that do exist.

Literature Review

First, it is important to understand the general context of job satisfaction and workplace conditions across the areas of focus in this study. In what follows, we provide a brief overview of the current contextual conditions of work within the U.S., Western European countries, and Nordic countries.

The U.S.

Although states within the U.S. are not homogeneous (Koven, 1999), there was general correlation within states of Americans employees with neuroticism and job dissatisfaction (McCann, 2018). Another prominent factor for the 52.3% of Americans claiming to be unhappy with their jobs (Adams, 2014) seemed to be a result of dealing with coworkers and management possessing traits such as narcissism, Machiavellianism, and psychopathy, or the “Dark Triad” (Jonason, 2015). Despite a high job dissatisfaction rate in America, work in America is a significant aspect in people’s lives, not only for extrinsic values, but for intrinsic values as well (McCortney & Engels, 2003). Despite the common belief that American businesses are anti-eco-friendly, there have been improvements to industrial ecology (Allenby, 2006). American industries that actively sought to combine industrial ecology to their business strategy found a positive impact to businesses and job satisfaction (Finster et al., 2002). The U.S. is considered to have a more individualistic style of thinking (House et al., 2004).

However, despite the United States individualistic style of thinking and overall job satisfaction, there was not enough information to pair an individualistic-culture workplace to job dissatisfaction (House et al., 2004).

Western European Countries

Collectively, countries in Western Europe have lower job satisfaction rates than Nordic countries (House et al., 2004). This could be explained by differences in work–life balance among these regions. Balance between work and family life are strong indicators of job satisfaction (House et al., 2004). When the demands of work hamper the pursuit of other life interests, it is likely to create a crisis and the resultant stresses and strains among the employees (Chandra, 2012). The absence of balance, typically conceived of as high levels of conflict between work and non-work domains, has been associated with higher turnover intentions and absenteeism and lower employee performance (Beham et al., 2012). Contrary to work–life balance, employees who feel highly secure in their jobs do not tend to have higher levels of job satisfaction. In terms of job characteristics, 3% and 89% of respondents in Western European countries regarded their jobs as highly insecure and highly secure, respectively (Borooah, 2009). Even though most workers feel secure in their jobs, job security is not necessarily a strong indicator of job satisfaction.

Nordic Countries

Among Nordic countries, Denmark is considered to have the highest job satisfaction among workers while Sweden is considered to have the lowest job satisfaction among workers (Eskildsen et al., 2004). While Denmark and Sweden were reported to have similar practices in in-group collectivism, institutional collectivistic practices between Denmark and Sweden had more variance—Sweden being more collectivistic in institutional practices (House et al., 2004). In the same study, there were reported differences in leadership characteristics (House et al., 2004). These differences in practice between Sweden and Denmark could lead to an explanation as to why these two countries have varying job satisfaction; however, further research is required. Nordic countries with high job satisfaction reported it to have been a result of flexicurity, with non-permanent yet secure jobs leading to job satisfaction (Origo & Pagani, 2009). Another reported factor to job satisfaction is age; job satisfaction in Nordic countries appears to increase with age (Eskildsen et al., 2004).

Theoretical Model

To understand the drivers of job satisfaction, we utilize a theoretical model developed by Andrade and Westover (2018a, 2018b), which synthesizes the literature to date in explaining the influences on the experiences of workers and their overall job satisfaction, as depicted in Figure 1. While many studies have pointed to the importance of various intrinsic, extrinsic, work relations, and work–life balance variables, this model also includes important contextual factors such as control variables for organizational and job characteristics. This model will be used below for conducting a comparison of job satisfaction and the perceived importance of varying intrinsic and extrinsic job quality characteristics in the U.S., Western European, and Nordic countries in 2015.

International Social Survey Program Methodological Description

As with any quantitative analysis, particularly one of a comparative international nature, it is important to understand the details behind the data sources, the variables involved, and the statistical methodology used. In what follows, we provide details on the data collection, key work characteristics variables related to job satisfaction, individual and family

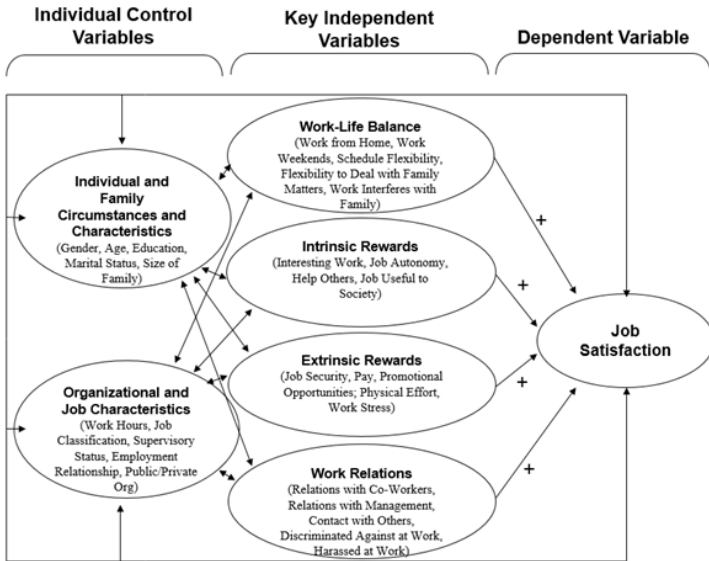


Figure 1. Drivers of job satisfaction.

circumstances and characteristics variables, organizational and job characteristics variables, and the statistical methodology used.

Description of Data

We used non-panel longitudinal data from the 2015 wave of the International Social Survey Program (ISSP) Work Orientations Modules IV, in particular various survey questions on job characteristics and job quality. The ISSP Work Orientations Modules used a multistage stratified probability sample to collect the data for each of the various countries with a variety of eligible participants in each country’s target population.¹ The Work Orientations module focuses on the areas of general attitudes toward work and leisure, work organization, and work content.² Variables of interest in the data collected by the ISSP are single-item indicators (i.e., with a single survey question for job satisfaction, interesting work, job autonomy, workplace relations, etc., on a Likert

¹ ISSP researchers collected the data via self-administered questionnaires, personal interviews, and mail-back questionnaires in 1996–97 and 2005.

² For a full summary and description of this research, see: <https://www.gesis.org/issp/modules/issp-modules-by-topic/work-orientations/2005/>.

scale). For the purposes of this study, the units of analysis start with individuals within the separate sovereign nations. In addition to examining one large sample including all respondents from all participating countries, we examined a separate sample for each country to determine which job characteristics best predict job satisfaction in that particular country and then make cross-national comparisons.

Key Work Characteristics Related to Job Satisfaction

We use Andrade and Westover's (2018a, 2018b) job satisfaction model (which built on Handel's (2005) job satisfaction model, which was based on Kalleberg's 1977 findings) for conducting a cross-national comparison of job satisfaction and the perceived importance of intrinsic and extrinsic job quality characteristic and work relations across countries (see also Spector 1997; Souza-Poza & Souza-Poza 2000; Muñoz de Bustillo Llorente & Macias, 2005). As seen in Table 1 below, following the approach of Handel (2005), 10 intrinsic and extrinsic variables were available for all countries in the 2015 Work Orientations data and thus used for this study. Additionally, we included important variables related to the meaning individuals give to their work, workplace discrimination/harassment, and work–life balance and schedule flexibility (in addition to a range of individual control variables).

Individual and Family Circumstances and Characteristics

While there are many possible control variables that would be helpful in this analysis, availability of all such variables is not consistent across all countries in the 2015 ISSP Work Orientations data. As such, control variables used in this analysis were limited to the following individual characteristics: (1) sex,³ (2) age,⁴ (3) years of education,⁵ (4) marital status,⁶ and (5) size of family⁷ (see Souza-Poza & Souza-Poza, 2000; Hodson, 2002; Carlson & Mellor, 2004).

³ Categories for this variable include: (1) Male, (2) Female.

⁴ Continuous variable.

⁵ Continuous variable.

⁶ Response categories for this variable include: (1) Married, (2) Civil partnership, (3) Separated from spouse/civil partner(s), (4) Divorced from spouse/legally separated, (5) Widowed/civil partner died, (6) Never married/never in a civil partnership

⁷ Continuous variable.

Table 1: Key Work Characteristics Related to Job Satisfaction	
Dependent Variable	
Job Satisfaction ^a	“How satisfied are you in your main job?”
Intrinsic Rewards ^b	
Interesting job	“My job is interesting.”
Job autonomy	“I can work independently.”
Help others	“In my job I can help other people.”
Job useful to society	“My job is useful to society.”
Extrinsic Rewards ^b	
Pay	“My income is high.”
Job security	“My job is secure.”
Promotional opportunities	“My opportunities for advancement are high.”
Physical effort ^c	“How often do you have to do hard physical work?”
Work stress ^c	“How often do you find your work stressful?”
Work Relations	
Management-employee relations ^d	“In general, how would you describe relations at your workplace between management and employees?”
Coworker relations ^d	“In general, how would you describe relations at your workplace between workmates/colleagues?”
Contact with others ^b	“In my job, I have personal contact with others.”
Discriminated against at work ^e	“Over the past 5 years, have you been discriminated against with regard to work, e.g., when applying for a job, or when being considered for a pay increase or promotion?”
Harassed at work ^e	“Over the past 5 years, have you been harassed by your supervisors or coworkers at your job, e.g., have you experienced any bullying, physical, or psychological abuse?”
Work–life Balance	
Work from home ^c	“How often do you work at home during your normal work hours?”
Work weekends ^c	“How often does your job involve working weekends?”
Schedule flexibility ^f	“Which of the following best describes how your working hours are decided (times you start and finish your work)?”

Flexibility to deal with family matters ^g	“How difficult would it be for you to take an hour or two off during work hours, to take care of personal or family matters?”
Work interferes with family ^c	“How often do you feel that the demands of your job interfere with your family?”

^a Response categories for this variable include: (1) Completely Dissatisfied, (2) Very Dissatisfied, (3) Fairly Dissatisfied, (4) Neither Satisfied nor Dissatisfied, (5) Fairly Satisfied, (6) Very Satisfied, (7) Completely Satisfied.

^b Response categories for these variables include: (1) Strongly Disagree, (2) Disagree, (3) Neither Agree nor Disagree, (4) Agree, and (5) Strongly Agree.

^c Response categories for this variable include: (1) Always, (2) Often, (3) Sometimes, (4) Hardly Ever, (5) Never.

^d Response categories for these variables include: (1) Very Bad, (2) Bad, (3) Neither good nor bad, (4) Good, and (5) Very Good.

^e Response categories for these variables include: (1) Yes, (2) No.

^f Response categories for this variable include: (1) Starting and finishing times are decided by my employer and I cannot change them on my own, (2) I can decide the times I start and finish work, within certain limits, and (3) I am entirely free to decide when I start and finish work.

^g Response categories for this variable include: (1) Not difficult at all, (2) Not too difficult, (3) Somewhat difficult, and (4) Very difficult.

Organizational and Job Characteristics

While there are many possible control variables that would be helpful in this analysis, availability of all such variables is not consistent across all countries in the 2015 ISSP Work Orientations data. As such, organizational and job characteristics control variables used in this analysis were limited to: (1) work hours,⁸ (2) ISCO job classification,⁹ (3) supervisory status,¹⁰ (4) employment relationship,¹¹ and (5) public/private organization¹² (see Souza-Poza & Souza-Poza, 2000).

⁸ Continuous variable.

⁹ Categories for this variable: (1) Managers, (2) Professionals, (3) Technicians and associate professionals, (4) Clerical support workers, (5) Services and sales workers, (6) Skilled agricultural, forestry and fishery workers, (7) Craft and related trades workers, (8) Plant and machine operators and assemblers, (9) Elementary occupations, and (10) Armed forces occupations

¹⁰ Categories for supervising others: (1) Yes, (2) No.

¹¹ Categories for this variable: (1) Employee, (2) Self-employed without employees, (3) Self-employed with employees, and (4) Working for own family's business.

¹² Categories for type of organization: (1) Public, (2) Private

Statistical Methodology

We analyzed work orientation and job satisfaction data from individual respondents in the 37 countries included in the 2015 Work Orientations wave of the ISSP. First, we performed a range of bivariate and multivariate analyses (e.g., correlations, cross-tabulations, trend analysis, ANOVA and ANCOVA procedures, and general descriptive statistics¹³) on the work characteristics and attitudes in each country, which provides a basis for making descriptive comparisons between countries. Additionally, we ran aggregate and country-specific Ordinary Least Squares (OLS) regression models to examine the differences between countries in the impact of individual work characteristics on job satisfaction. It is worth noting that some studies examining worker satisfaction have used OLS regression (see Handel, 2005), while others have pointed to ordered probit regression (used when the dependent variable is ordered and categorical). We ran identical models using both OLS and ordered probit procedures (see Souza-Poza and Souza-Poza, 2000). Upon comparing the OLS and ordered probit results, we have come to the same conclusion that for the purposes of comparing coefficients and significance across countries and across models, as well as for overall ease of interpretation of the results, OLS is sufficient (however, full ordered probit results are all available upon request).

A Note on Cross-Cultural Variations in International Research

In any research comparing data from various countries throughout the world, cross-cultural variation and culturally motivated bias in responses is always an issue. Thus, because of the cross-national comparative nature of this research, it is important to understand the possible implications of culturally motivated biased perceptions in responses. Sousa-Poza and Sousa-Poza state, “If the questionnaire or the topic being studied is ‘ethnically biased,’ then errors in perception will occur” (2000: 521). Indeed, a cross-national analysis of subjective variables can produce a number of data and methodological problems. However, several researchers have found that individuals compare their situation with those around them and that happiness and well-being are based on this

¹³ All correlations, cross-tabulations, ANOVA, ANCOVA, post-hoc tests, and full descriptive statistics have not been included here due to space limitations, but are available upon request. Additionally, appropriate tests for multicollinearity were conducted. There are no issues with multicollinearity of variables in the OLS model. Additionally, all outliers were Winsorized in the initial data cleaning stages, prior to final models and analysis.

relative comparison (Clark and Oswald, 1996; Diener et al., 1995). Furthermore, most studies examining job satisfaction are based on this type of data (Sousa-Poza and Sousa-Poza, 2000).

Despite these data and methodological problems, data standardization, as an adjustment of raw scores in cross-cultural research to correct for such response tendencies, is used to reduce or eliminate unwanted cross-cultural differences that are not due to variables of interest, but rather response sets and methodological artifacts (see Hofstede 1980). Detecting potential response bias requires researchers to identify different response patterns based on particular methods used and eliminate them.

ISSP Results

Descriptive Statistics

Figure 2 shows mean job satisfaction levels across the ten 2015 ISSP countries included in this analysis. Additionally, Table 2 shows the means of all additional model variables, by country.¹⁴ Of note is the general variation across countries. The highest job satisfaction levels among these ten countries were in Switzerland (means score of 5.76), while France (5.12) and Sweden (5.22) have job satisfaction levels lower than the global average of 5.3 (of all 37 countries included in the 2015 ISSP Work Orientations data). Most countries in this analysis have a mean job satisfaction scores in the 5.3–5.5 range.

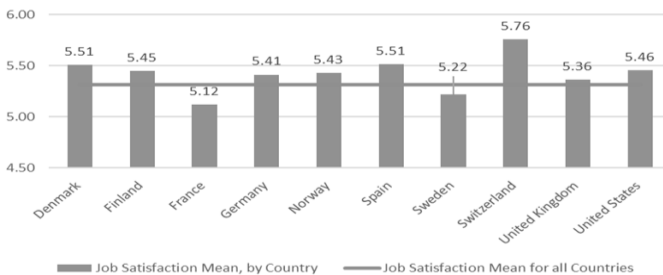


Figure 2: Mean job satisfaction, by country

¹⁴ ANOVA and ANCOVA tests confirm statistically significant difference in mean job satisfaction scores and other work characteristic variables across the 10 countries. Full summary statistics, including medians and standard deviations, are not presented here due to space limitations, but are available upon request.

Table 2: Mean Scores of Job Satisfaction and Main Study Variables by Country, 2015

VARIABLE	Denmark	Finland	France	Germany	Norway	Spain	Sweden	Switzerland	United Kingdom	United States	All Countries
Job Satisfaction	5.51	5.45	5.12	5.41	5.43	5.51	5.22	5.76	5.36	5.46	5.32
Interesting Work	4.23	4.01	3.96	4.19	4.09	3.84	3.98	4.36	3.96	4.02	3.83
Job Autonomy	4.38	4.14	3.84	4.29	4.18	3.57	4.11	4.33	4.09	4.12	3.82
Help Others	4.15	3.95	3.84	3.68	4.03	3.81	3.93	4.14	4.07	4.30	3.88
Job Useful to Society	4.07	3.88	3.87	3.91	4.06	3.97	4.00	4.12	3.89	4.14	3.94
Job Security	3.87	3.58	3.54	4.09	3.88	3.65	3.99	4.08	3.66	3.96	3.77
Pay	3.01	2.92	2.50	2.90	2.87	2.68	2.96	3.14	2.78	2.79	2.82
Promotional Opportunities	2.70	2.67	2.29	2.94	2.60	2.50	2.98	3.05	2.95	3.09	2.78
Physical Effort	2.58	2.55	2.69	2.47	2.39	2.68	2.65	2.49	2.61	3.48	2.71
Work Stress	3.16	3.25	3.42	3.23	3.32	3.28	3.48	3.13	3.27	3.22	3.17
Relations with Coworkers	4.23	4.18	4.02	4.38	4.36	4.32	4.30	4.49	4.36	4.12	4.19
Relations with Management	3.79	3.83	3.51	4.13	3.81	4.05	3.76	4.18	3.95	3.96	3.91
Contact with Others	4.57	4.30	4.25	4.47	4.36	4.34	4.37	4.51	4.37	4.47	4.23
Discriminated Against at Work	1.8338	1.85	1.80	1.77	1.88	1.81	1.82	1.83	1.89	1.79	1.82
Harassed at Work	1.83	1.80	1.76	1.89	1.86	1.91	1.87	1.86	1.83	1.79	1.86
Work from Home	--	4.03	4.05	4.28	3.93	4.29	4.07	4.10	4.07	3.98	4.00
Work Weekends	--	3.38	3.32	3.45	3.23	3.04	3.46	3.41	3.09	2.93	3.14
Schedule Flexibility	1.84	1.82	1.57	1.73	1.67	1.52	1.82	1.82	1.58	1.63	1.63
Flexibility to Deal with Family Matters	1.94	1.94	2.56	2.30	2.11	2.11	1.95	1.91	2.15	1.95	2.25
Work Interferes with Family	3.48	3.52	3.37	3.45	3.62	3.46	3.36	3.62	3.38	3.48	3.66
Age	--	44.99	44.61	43.39	45.09	43.01	47.29	43.22	44.06	43.58	43.37
Education	15.19	14.67	15.15	13.40	14.16	13.71	14.07	13.73	15.21	14.16	13.34
Size of Family	2.71	2.71	2.90	2.73	2.83	3.10	2.80	2.91	2.61	2.53	3.23
Work Hours	37.06	38.04	37.81	37.78	37.19	40.23	38.64	38.24	37.94	41.43	40.96

Regression Results

We ran a separate OLS regression analysis for each of the 10 countries of interest from the 2015 ISSP Work Orientations module. We provide a breakdown of OLS model specifications by country in Table 3 (reporting the comparative predictability (adjusted r -squared) of each country model and the standardized beta coefficient and significance for each of the key independent variables in the model). Additionally, Figure 3 demonstrates there is a great deal of variation among countries in standardized beta coefficient strength and statistical significance across study variables. Of particular note is that the model only explains 40% and 41% of the variation in job satisfaction in Switzerland and Spain, respectively (adjusted r -squared = 0.40), the worst model fit of all 10 countries in this analysis. In contrast, for all 37 countries from the 2015 ISSP data, the model explains 43% of the variation in job satisfaction (adjusted r -squared = 0.43), and each of the remaining 8 countries from this focused analysis are above that level, with the clear winners being Sweden, Finland, and Denmark, where the model explains 58%, 57%, and 56% of the variation in job satisfaction, respectively.

Additionally, we see several patterns emerge when we compare country-specific variations in the OLS regression results (Table 3). First of all, interesting work is significant in every country, and other certain variables are significant in nearly every country, including pay, work

Table 3: OLS Regression Results of Job Satisfaction and Main Study Variables by Country, 2015

VARIABLE	Denmark	Finland	France	Germany	Norway	Spain	Sweden	Switzerland	United Kingdom	United States	All Countries
Interesting Work	0.441***	0.413***	0.347***	0.325***	0.369***	0.239***	0.419***	0.376***	0.363***	0.388***	0.287***
Job Autonomy	0.003	0.021	0.035	0.093**	0.024	0.070*	0.029	0.013	0.033	-0.028	0.019**
Help Others	0.019	0.026	0.080	-0.033	0.003	-0.010	0.099*	0.036	-0.002	0.023	0.022**
Job Useful to Society	-0.047	0.025	-0.031	-0.019	0.001	0.074	-0.022	0.059	-0.047	0.003	0.037***
Job Security	0.109***	0.069*	-0.013	0.059*	0.072*	0.042	0.078**	0.076*	0.037	0.073**	0.063***
Pay	-0.009	0.135***	0.123**	0.081*	0.182***	0.100**	0.014	0.022	0.076*	0.102**	0.098***
Promotional Opportunities	0.129***	0.060	0.106*	0.018	0.073*	0.067	0.110**	0.131**	0.107***	0.057	0.057***
Physical Effort	0.108**	0.001	0.013	0.045	0.070*	-0.037	-0.057	0.056	0.097**	0.000	0.005
Work Stress	-0.051	-0.163***	-0.123**	-0.183***	-0.084*	-0.035	-0.150***	0.000	-0.162***	-0.103***	-0.086**
Relations with Coworkers	0.162***	0.070*	0.144***	0.075*	0.136***	0.062	0.137***	0.066*	0.090**	0.024	0.085***
Relations with Management	0.130***	0.253***	0.259***	0.176***	0.220***	0.238***	0.183**	0.183**	0.290***	0.212***	0.225***
Contact with Others	0.082*	0.012	-0.011	0.066*	0.036	0.026	-0.033	-0.042	-0.016	0.057*	0.010
Discriminated Against at Work	0.067*	-0.022	-0.021	0.103***	-0.001	0.103**	0.036	-0.024	-0.036	0.119***	0.037***
Harassed at Work	0.009	0.011	0.015	-0.002	0.007	0.017	-0.002	0.008	0.061*	0.001	0.019**
Work from Home	-	-0.045	-0.020	0.026	0.000	0.007	0.066	-0.025	0.025	-0.002	0.005
Work Weekends	-	0.013	-0.055	-0.057	-0.089**	-0.023	-0.055	0.027	-0.025	-0.012	-0.023**
Schedule Flexibility	0.051	0.048	-0.065	0.044	-0.017	-0.033	0.043	0.067	0.019	0.034	0.014*
Flexibility to Deal with Family Matters	-0.071*	0.028	-0.042	-0.060	-0.060	-0.050	-0.038	-0.060	-0.023	-0.048	-0.036**
Work Interferes with Family	0.135***	0.121**	0.080	0.122***	0.110**	0.050	0.074*	0.079*	0.087**	0.065*	0.097***
Gender	0.001	0.010	-0.022	0.003	-0.007	0.063*	0.002	0.025	0.053	0.020	0.005
Age	-	0.080*	0.044	0.041	0.033	-0.007	-0.001	0.124**	0.094**	0.049	0.033***
Education	0.007	0.000	-0.041	-0.035	-0.012	-0.054	-0.026	-0.036	-0.049	-0.117**	-0.045**
Marital Status	-0.076*	0.037	0.012	-0.014	-0.035	-0.002	0.030	0.001	-0.043	-0.069*	-0.028**
Size of Family	-0.046	0.014	0.030	0.020	-0.011	-0.020	-0.059	0.041	-0.007	-0.015	-0.007
Work Hours	0.030	-0.045	-0.034	0.034	0.001	0.025	0.002	0.015	0.002	0.072**	0.006
Job Classification	0.034	0.096	-0.038	0.007	0.082*	0.048	0.078*	0.025	-0.011	0.040	-0.009
Supervisory Status	0.045	-0.034	0.034	0.056	0.013	0.001	0.017	0.022	0.009	0.002	-0.004
Employment Relationship	0.037	-0.026	0.022	0.002	-0.016	-0.022	0.040	-0.051	0.049	0.019	0.008
Public/Private Organization	-0.007	-0.002	-0.057	-0.009	-0.054	-0.044	-0.046	-0.029	-0.069*	-0.035	-0.028**
N	547	464	462	741	622	656	564	682	737	812	18,716
ADJ. R-SQUARED	0.564	0.573	0.475	0.460	0.500	0.414	0.579	0.401	0.549	0.473	0.428
F	28.11**	22.45**	15.38**	22.74**	24.42**	16.93**	27.72**	16.69**	31.89**	26.06**	483.58**

interferes with family. However, the significance of most other variables (including control variables) vary widely across different countries. One variation of particular note is the difference in the significance of working weekends on employee job satisfaction across samples. Working weekends is significant only in Norway and for the overall sample (the more you work weekends, the lower your job satisfaction),

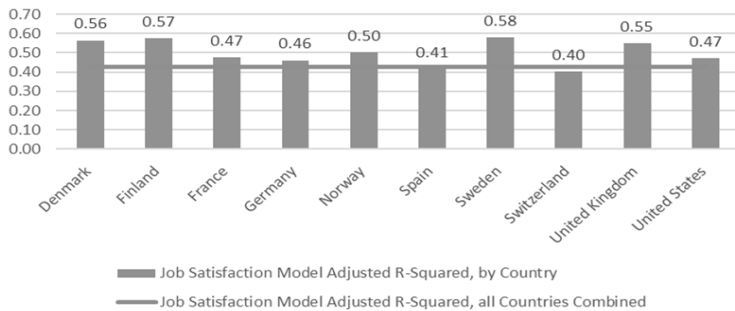


Figure 3: Model fit: job satisfaction model adjusted r-squared, by country

but not in any of the other country samples. One possible reason for this result is the heightened importance of work–life balance in Norway. However, this does not explain why this variable is not significant in other Nordic countries, which experience similar attitudes related to the importance of work–life balance. Further research should explore this inconsistency in results. Despite some paradoxes (the results raise as many questions as they answer), these regression findings clearly show that there are statistically significant cross-national differences in the levels of job satisfaction across countries and in the determinants of job satisfaction across countries.

Insights from GLOBE Cross-Cultural and Leadership Dimensions Data

As there are clearly cross-national differences in the nature of work and job satisfaction in the U.S., Western European countries, and Nordic countries, the question remains, why? As noted previously, cross-cultural researchers have long suggested that these differences are due to cultural differences in each country. To help explore this question within this set of countries, we used aggregate descriptive cross-cultural and leadership dimension data from the GLOBE project.

Cross-Cultural Characteristics from the GLOBE Project

When looking at cross-cultural variables in the GLOBE project, we can see aggregate scores by country of the societal values of each cultural characteristic, as compared with the societal practice associated with each cultural characteristic. These main cross-cultural dimensions include: (1) Uncertainty avoidance, (2) Future orientation, (3) Power distance, (4) Institutional collectivism, (5) Humane orientation, (6) Performance orientation, (7) In-group collectivism, (8) Gender egalitarianism, and (9) Assertiveness.

The results of the cultural practices and values are placed on a 1–7 scale, where “1” represents a cultural practice or value and “7” represents a differing—often opposing—cultural practices or value. For example, if “7” represents individualistic interests and “1” represents collectivistic interests, a “4.5” would mean that that the country would have both individual and collective interests, but leans toward individualistic thinking. The data include the findings “as is” and not what the data would assumed to be, or “should be.”

Table 4 provides the descriptive summary data of GLOBE societal values and practice for each of the 10 countries included in this analysis. Each cultural dimension will be explored briefly below.

Table 4: GLOBE Cross-Cultural Societal Values and Practice, by Country

	Denmark	Finland	France	Germany (East)	Germany (West)	Norway	Spain	Sweden	Switzerland	England	USA	Average
Uncertainty Avoidance Societal Practices	5.22	5.02	4.43	5.16	5.22		3.97	5.32	5.37	4.65	4.15	4.85
Future Orientation Societal Practices	4.44	4.24	3.48	3.95	4.27		3.51	4.39	4.73	4.28	4.15	4.14
Power Distance Societal Practices	3.89	4.89	5.28	5.54	5.25		5.52	4.85	4.9	5.15	4.88	5.02
Collectivism I Societal Practices (Institutional Collectivism)	4.8	4.63	3.93	3.56	3.79		3.85	5.22	4.06	4.27	4.2	4.23
Humane Orientation Societal Practices	4.44	3.96	3.4	3.4	3.18		3.32	4.1	3.6	3.72	4.17	3.73
Performance Orientation Societal Practices	4.22	3.81	4.11	4.09	4.25		4.01	3.72	4.94	4.08	4.49	4.17
Collectivism II Societal Practices (In-group Collectivism)	3.53	4.07	4.37	4.52	4.02		5.45	3.66	3.97	4.08	4.25	4.19
Gender Egalitarianism Societal Practices	3.93	3.95	3.64	3.06	3.1		3.01	3.84	2.97	3.67	3.34	3.39
Assertiveness Societal Practices	3.8	3.81	4.13	4.73	4.55		4.42	3.38	4.51	4.15	4.55	4.2
Uncertainty Avoidance Societal Values	3.82	3.85	4.26	3.94	3.32		4.76	3.6	3.16	4.11	4	3.88
Future Orientation Societal Values	4.33	5.07	4.96	5.23	4.85		5.63	4.89	4.79	5.06	5.31	5.01
Power Distance Societal Values	2.76	2.19	2.76	2.69	2.54		2.26	2.7	2.44	2.8	2.85	2.6
Collectivism I Societal Values (Institutional Collectivism)	4.19	4.11	4.88	4.88	4.82		5.2	3.94	4.89	4.31	4.17	4.5
Humane Orientation Societal Values	5.45	5.81	5.67	5.44	5.46		5.69	5.65	5.54	5.43	5.53	5.57
Performance Orientation Societal Values	5.61	6.11	5.65	6.09	6.01		5.8	5.8	5.82	5.9	6.14	5.89
Collectivism II Societal Values (In-group Collectivism)	5.5	5.42	5.42	5.22	5.18		5.79	6.04	4.94	5.55	5.77	5.48
Gender Egalitarianism Societal Values	5.08	4.24	4.4	4.5	4.89		4.82	5.15	4.92	5.17	5.06	4.86
Assertiveness Societal Values	3.39	3.88	3.38	3.23	3.09		4	3.81	3.21	3.71	4.32	3.96

Uncertainty Avoidance in Society Practice/Value

Uncertainty avoidance in this study refers to societal orderliness and consistency being enforced. The closer the data are to “1,” the greater the disagreement the society has of enforcing orderliness. Thus, the closer the data are to “7,” the greater the agreement the society has to enforcing orderliness. Denmark, Finland, Germany (East/West), Sweden, and Switzerland all vary from value to practice at a larger quantity than France, Spain, England, and the U.S. (House et al., 2004).

Future Orientation Society Practice/Values

The closer the data are to “7,” the more likely the society is to make plans for the future, whereas the closer the data are to “1” the more likely they are to accept the status quo as well as solve current problems. Spain showed the most variance in societal values vs. practices, while the rest of the data show that the other societies tested remained relatively close to practices and values they showed (House et al., 2004).

Power Distance

Power distance on this particular scale refers to employees questioning their boss when within a disagreement. The closer the number is to “1,” the more likely an employee will question their boss. Thus, “7” is the likelihood of an employee complying with authority figures. All of the values data collected by the differing societies varied greatly when compared with their practices (House et al., 2004).

Societal-Level Institutional Collectivism Practices/Values

Societal-level institutional collectivism practices refers to leaders encouraging solidarity within a group, even if individual goals suffer. The closer the result is to “7,” the greater the agreement with collectivist practice there is. The closer the result is to “1” the stronger disagreement with collectivist practices. Spain and Sweden both vary from value and practice. According to the data, Spain practices a more institutional collectivistic approach. This differentiates from the data in that the data show that Spain’s values lean more toward an institutional individualistic approach. Opposite from Spain, Sweden has a higher agreement with institutional collectivistic in practice (House et al., 2004).

Humane Orientation: Society Practices/Values

Humane orientation refers to the consideration towards others that a society has. The closer the data are to “1,” the less concerned about others the society is, and the closer the data are to “7,” the more concerned a society is towards others. All data collected show a fairly high score in humane orientation value; however, the data also show a large variance from the values when compared with practice. Denmark, the U.S., and Sweden scored the highest in humane orientation practices (House et al., 2004).

Performance Orientation and Society Practices/Values

Society performance orientation refers societal practices and values in which individuals are encouraged to continuously improve their skills. The closer the data are to “1,” the greater the disagreement for the encouragement of continuous student skill improvement. The closer the data are to “7” the greater the agreement will take place. Switzerland had a high score in both practice and value with little variance. The rest of the data collected show that the remaining societies have higher scores in performance orientation values than practices (House et al., 2004).

Societal-Level In-Group Collectivism Practices

The closer the statistics are to “7,” the more likely a child was to agree with taking pride in the parents’ accomplishments, whereas the closer the values to “1,” the more likely they were to disagree. The same would be true of parents’ pride in their children’s accomplishments (House et al., 2004).

Gender Egalitarianism Scale-Societal Practices/Values

Gender egalitarianism refers to boys being more encouraged than girls to pursue a higher education, with a “7” indicating the society is

more likely to disagree with encouraging boys more than girls. The closer the value gets to “1,” the more likely the country would agree with encouraging boys more than girls to attain a higher education. All the societies scored high on the gender egalitarianism values, but Denmark, when compared with the other societies, had the least variance, and highest practice in gender egalitarianism (House et al., 2004).

Assertiveness in Societal Practices/Values

The closer the number is to “1” in the data, the more kind and nonassertive the culture finds itself. The closer a number is to “7,” the more assertive the country is considered to be (House et al., 2004).

Leadership Dimensions from the GLOBE Project

In addition to the cross-cultural dimension variables, the GLOBE project provides aggregate descriptive data on country-level leadership dimensions, including the following overarching categories: (1) Charismatic/value-based global leadership, (2) Humane-oriented global leadership, (3) Team-oriented global leadership, (4) Participative global leadership, (5) Autonomous global leadership, and (6) Self-protected global leadership.

Table 5 provides the descriptive summary data of GLOBE global leadership dimensions for each of the 10 countries included in this analysis. Each leadership dimension will be explored briefly below.

Charismatic/Value-based Global Leadership Dimension

This reflects the ability to inspire, motivate, and expect high performance outcomes from others based on firmly held core values (House et al., 2004). While there is not a large difference, leaders in the U.S. are more likely than leaders in the other two regions being examined to exude charismatic qualities. The leadership dimensions that are included in the charismatic/value-based global leadership dimension are visionary, inspirational, self-sacrifice, integrity, decisive, and performance oriented (House et al., 2004).

Humane-Oriented Global Leadership Dimension

Humane-oriented leadership reflects supportive and considerate leadership and includes compassion and generosity (House et al., 2004). There is a large gap between how humanely leaders in the U.S. treat their

Table 5: GLOBE Leadership Dimensions, by Country

Variable	England	Finland	France	Poland	Spain	Switzerland	Sweden	Germany (EAST)	Germany (WEST)	Denmark	USA	All Countries
Charismatic 1: Visionary	6.21	6.29	5.06	6.03	5.91	6.12	6.05	5.96	5.99	6.20	6.28	6.00
Charismatic 2: Inspirational	6.39	6.42	5.22	5.87	6.34	6.25	6.31	6.10	6.15	6.26	6.35	6.15
Charismatic 3: Self-sacrifice	4.90	4.22	3.98	4.61	4.80	4.88	4.81	5.08	4.87	5.05	5.16	4.76
Integrity	6.12	6.52	5.14	5.58	6.11	6.36	6.23	6.11	6.12	6.38	6.51	6.11
Decisive	6.00	5.37	5.06	6.00	5.95	5.86	5.53	5.81	5.78	6.08	5.36	5.82
Performance Oriented	6.38	6.04	5.10	5.87	6.25	6.08	5.96	6.33	6.11	6.05	6.46	6.06
Charismatic/Value-based Global Leadership Dimension	6.01	5.34	4.93	5.67	5.90	5.93	5.84	5.87	5.84	6.00	6.12	5.82
Team 1: Collaborative Team Orientation	5.33	5.54	4.73	5.55	5.72	5.25	5.50	5.08	5.05	5.28	5.38	5.31
Team 2: Team Integrator	6.16	6.35	5.11	6.03	6.26	5.93	5.98	5.37	5.48	6.13	6.03	5.86
Diplomatic	5.40	5.41	5.01	6.01	5.73	5.27	5.27	5.10	5.08	5.32	5.46	5.37
Malevolent (Negatively Attributed)	1.74	1.47	1.95	1.77	1.77	1.60	1.52	1.71	1.68	1.51	1.55	1.66
Administratively Competent	5.35	5.32	4.53	6.11	5.66	5.51	5.44	5.74	5.51	5.34	5.63	5.45
Team-Oriented Global Leadership Dimension	5.71	5.85	5.11	5.98	5.93	5.61	5.75	5.51	5.49	5.70	5.80	5.68
Participative	5.68	5.32	6.14	5.28	4.83	5.80	5.49	5.47	5.72	5.70	5.90	5.63
Autocratic	2.55	2.11	2.36	3.21	2.60	1.91	2.41	2.06	1.95	2.10	2.03	2.30
Participative Global Leadership Dimension	5.57	5.91	5.90	5.04	5.11	5.94	5.54	5.70	5.88	5.80	5.93	5.67
Modesty	4.91	4.52	4.27	5.00	4.76	4.88	4.53	4.81	4.61	4.32	5.24	4.72
Humane-oriented	4.91	4.06	3.29	4.03	4.57	4.65	4.96	4.36	4.27	4.18	5.19	4.41
Humane-Oriented Global Leadership Dimension	4.90	4.30	3.82	4.56	4.66	4.76	4.73	4.60	4.44	4.23	5.21	4.57
Autonomous	3.92	4.08	3.32	4.34	3.54	4.13	3.97	4.95	4.30	3.79	3.75	3.95
Autonomous Global Leadership Dimension	3.92	4.08	3.32	4.34	3.54	4.13	3.97	4.35	4.30	3.79	3.75	3.95
Self-centred	1.94	1.55	1.86	2.10	1.84	2.00	1.79	2.20	2.10	1.95	1.97	1.94
Status Conscious	3.70	3.15	3.35	4.54	4.23	3.81	3.30	4.45	3.72	4.07	3.60	3.81
Internally Competitive, Originally Labeled "Conflict Inducer"	3.42	3.10	3.41	4.05	4.24	3.36	3.33	4.14	3.59	3.03	3.53	3.57
Face-saver	2.54	2.05	2.19	3.10	2.48	2.48	2.39	2.46	2.36	2.21	2.68	2.45
Bureaucratic, Originally Labeled "Procedural"	3.54	2.87	3.17	3.89	4.11	3.00	3.15	3.40	3.00	2.82	3.30	3.30
Self-Protective Global Leadership Dimension	3.04	2.55	2.81	3.52	3.38	2.92	2.81	3.32	2.96	2.81	3.15	3.03
Mean of Each Dimension	4.62	4.43	4.01	4.71	4.65	4.51	4.48	4.57	4.45	4.46	4.63	4.51

employees when compared with leaders in Western Europe and Nordic countries. The U.S. had the highest score (5.21). Western Europe and Nordic countries scored 4.53 and 4.46, respectively. As a whole, leaders in the U.S. have the most amount of concern towards others.

Team-Oriented Global Leadership Dimension

This dimension emphasizes effective team building and implementation of a common purpose or goal among team members (House et al., 2004). When it comes to the team-oriented global leadership dimension, there is not much of a difference between the regions being studied. The U.S. and Nordic countries scored virtually identically, with Western European countries following close behind. Leaders emphasize these characteristics among team members at close to the same rates.

Participative Global Leadership Dimension

Participative leadership reflects the degree to which managers involve others in decision-making and implementing processes (House et al., 2004). Although it is close, leaders in the U.S. are more likely to have this characteristic.

Autonomous Leadership

This refers to independent and individualistic leadership attributes (House et al., 2004). Nordic countries have higher rates of leaders who

are independent, autonomous, and have unique attributes. Leaders in Western Europe and the U.S. are not far behind.

Self-protected Global Leadership Dimension

This dimension focuses on ensuring the safety and security of the individual and group through status enhancement and face saving (House et al., 2004). Self-protected global leadership dimension is the variable with the smallest spread. Given the results of the humane-oriented global leadership dimension, this variable shows that leaders think and act more alike when something concerns themselves rather than others.

Implications and Conclusions

These results show that intrinsic and extrinsic work characteristics, workplace relationships, work–life balance, and scheduling flexibility conditions all strongly impact worker job satisfaction across the 10 countries in the study, although there are variations in saliency of each variable across countries. Therefore, it is important for any work organization (such as multinational corporations, global nongovernmental organizations, local and national governments, and labor unions) to understand that individual workers in different countries face unique country-contextual conditions that impact their experience in the workplace.

Additionally, examining the gap between the status of work–life balance and what is considered desirable for increased job satisfaction, as determined in this study suggests managers should consider increasing scheduling flexibility. This might entail offering variability in start and end times, working from home, and split-week schedules. Existing literature supports this suggestion, which demonstrates that various flex-time options increase job satisfaction and, in particular, improve performance at work and enrichment at home. Companies trying to brand themselves as attractive employers because of their employee-friendly work–life balance culture can use this label of ‘family-supportive organization’ to attract, retain, and develop critical talent in tight labor markets. They can use this label to highlight their employees’ high levels of work satisfaction and low turnover intentions.

Also of interest is the finding that intrinsic rewards accounted for the largest variation in job satisfaction in the model. As such, managers may want to consider strategies for increasing intrinsic motivation, which might include recognition programs or nonfinancial incentives, which are associated with increased job satisfaction and self-efficacy. Extrinsic rewards accounted for the second highest variation. Managers

in global contexts need to consider their approaches carefully, as extrinsic rewards may counter intrinsic motivation and make work-related goals less meaningful.

Ever since Hackman and Oldham's (1976) job characteristics model of job satisfaction, researchers have made modest variations to this earlier foundational work to develop a variety of job satisfaction models. Among those job satisfaction models still used today, arguably none are as commonly used as the one developed by Kalleberg (1977) and used by Handel (2005) and countless others. In each case, this commonly accepted model has been considered to be widely generalizable across a wide variety of cross-cultural and cross-national contexts. For example, in our analysis, we observe differences in work flexibility that might be based on labor costs, as well as cultural influences. Similarly, schedule volatility seems to be another factor that might see comparable developments. However, as demonstrated previously, Kalleberg (1977) and Handel's (2005) broadly accepted job satisfaction model is not simply duplicable across countries around the world, even when those countries seem somewhat similar in cross-national and cross-cultural contexts. Rather, what is commonly considered a widely generalizable job satisfaction model actual holds up very differently in countries around the world, with overall predictability and job satisfaction determinants' significance levels varying considerably across nations. Therefore, researchers should take great caution in comparing results from different job satisfaction studies performed around the world. Rather, a new and expanded model of job satisfaction, one that takes into account cross-cultural and country-contextual differences, is vitally needed.

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Perceptions of the Excellent Special Education Teacher's Expertise: Informing Teacher Preparation and Development

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Abstract

The Individuals with Disabilities Education Improvement Act requires that students with special needs be educated in the 'least restrictive environment,' which demands that all educators interact frequently. Previous research has suggested that educators outside of special education still struggle to work effectively with this unique student population. Using a transcendental phenomenological approach, the present study examined the lived experiences as revealed in interviews of 60 special and general educators and school administrators. The object was to describe the dispositions and skills that can make a good special educator an excellent one and how the expression of these abilities can affect relationships among these groups of professionals. A process of horizontalization and reduction was used to analyze the data, identifying five themes from the data set. The results revealed that the lived experiences among the respondents indicate that more opportunities need to be made available to educators to help them learn

to interact more effectively with students with special needs in the general education classroom.

Introduction

All teachers have the responsibility to teach all students. For general education teachers, this means that they will have, among others, students with special needs in their classrooms throughout their careers. The Individuals with Disabilities Education Improvement Act (IDEIA) requires that students with special needs be educated in the ‘least restrictive environment’ (LRE), which is often defined as the general education classroom (O’Connor et al., 2016). Because of this mandate, educators are expected to interact more often to create the LRE. Rock et al. (2016) have called for changes in education that can lead to the creation of an environment of ‘we’ that can better meet the demands of teaching students with special needs by all educators. Numerous studies have suggested, however, that general education teachers are not fully aware about how to make the inclusive setting a successful learning environment for students with special needs (Shevlin et al., 2013). Teachers come to the classroom with knowledge, beliefs, and dispositions, whether they are learned from personal experience or through teacher education courses (Lortie, 1975; Sharma & Sokal, 2015). Research suggests that knowledge, beliefs, and dispositions can also be taught and/or altered through teacher preparation programs (TPPs) and/or professional development (PD). Similarly, throughout their careers, some teachers who excel in their specific teaching areas can provide valuable insight into teaching (Stronge et al., 2016). But for these superior traits and abilities to inform the teacher education curriculum, they must first be identified (Stuart & Thurlow, 2000; Tam, 2015). This study looks to determine what the abilities of excellent special education teachers are according to special education teachers, general education teachers, and administrative professionals. Further, the study examines how the expression of these abilities can potentially influence relationships among these groups to help create this environment of ‘we.’

Review of the Literature

Inclusive Education

When it was first instituted through IDEIA, inclusive education was viewed as educators providing services for students with special needs in mainstream classrooms (Anderson & Boyle, 2015; Pellegrino

et al., 2015). Over time, however, the term shifted to encompass the larger picture that includes delivering quality education to all students and involves of all types of educators (Anderson & Boyle, 2015; Messiou, 2017). In the inclusive environment, students with various types of disabilities are educated with and as adequately as their nondisabled peers (Pellegrino et al., 2015). The LRE requires certain in-class supports from various educators (Crawford, 1994, as cited in Timmons, 2008; Salend, 2001). Because of this demand, Shevlin et al. (2013) suggested that tenets of inclusive education touch on teacher knowledge. These authors continued by pointing out that inclusive education required expertise among the educators that can be specific to their area but needed to be combined with the expertise of others to create an optimal learning environment for the students. Florian (1998) suggested that inclusive teaching is largely dependent upon a reconceptualization of teaching roles and responsibilities. Further, it demanded a move from viewing education as a deficit model of abilities to one that included, rather than excluded, all students (Ainscow & Sandill, 2010).

Teacher Knowledge

Through collaboration, the various teachers working in the inclusive environment come to possess specific professional knowledge, which can be developed and shared. This is a valuable resource. Many of these differences stem from their specific TPPs or tracks through the TPP, where general and special education teachers have been exposed to variants of basic teaching knowledge. Further, the specific teacher groups gain experience with their specific group of students. What the teachers gain through these experiences is generally referred to as teacher knowledge. Grossman (1990) developed a framework of teacher knowledge built on four 'cornerstones,' namely 1) subject matter knowledge, 2) general pedagogical knowledge, 3) pedagogical content knowledge, and 4) knowledge of context. This framework encompasses the appropriate expertise in content and pedagogy, how the expertise impacts students, and knowledge of students that Keeley, Ismail, and Buskist (2016) posit are the traits and abilities of an excellent teacher (see also Bain, 2004; Kreber, 2002; Revell & Wainwright, 2009; Shim & Roth, 2009; Skelton, 2004). Keeley, Ismail, and Buskist also state that ability in one area is not enough but that they work together in harmony. It would be expected that, as special educators continue in their professional development, these skills and traits would grow and synthesize throughout their careers.

Subject matter knowledge

Subject matter knowledge (SMK) is a teacher's understanding of their teaching area as a subject matter specialist. According to Grossman and Richert (1988), SMK includes knowledge of the content of one's subject area, including major concepts from the field and the relationships among concepts. SMK is divided into three subareas: knowledge of content, substantive knowledge, and syntactic knowledge. Knowledge of content is the central facts within a given subject area and their relationship to one another. Substantive knowledge includes central concepts and theories of the subject. Syntactic knowledge consists of knowledge about the subject, combined with the ideas and perspectives included in the subject area. SMK helps teachers know why content area themes are organized as they are and is directly related to how they present the subject to students.

General pedagogical knowledge

General pedagogical knowledge (GPK) is a body of knowledge about learners, learning, general principles of instruction, and the aims and purposes of education (Grossman, 1990). This type of knowledge includes basic concepts of teaching and is adjustable to subject-specific contexts. Grossman's model further breaks this type of knowledge down into three subcomponents: learners and learning, classroom management, and curriculum and instruction. Learners and learning concerns the students as learners and how they will be taught, while classroom management is the manner in which the classroom is structured to promote learning. Finally, curriculum and instruction consider the way in which the course content is arranged and the instructional tasks that promote instruction.

Pedagogical content knowledge

Pedagogical content knowledge (PCK) includes knowing how to make course content comprehensible for students and is grounded in a specific content area. Grossman divides PCK into four major parts. First is the overarching component of the teacher's conceptions of the purposes of teaching content, which contains the beliefs of the hows and whys of the value of teaching a specific content area. Next is teacher's knowledge of the students' understanding of the subject so that they can adjust instruction appropriately. Curricular knowledge is the third subcomponent of PCK, which addresses the knowledge of the numerous tools and materials that are available and when to use them. The last part of PCK is instructional strategies, techniques, and exercises that teachers use while teaching. Similarly, Magnusson et al. (1999) suggested that

PCK is influenced by subject matter knowledge and beliefs, pedagogical knowledge and beliefs, and knowledge and beliefs about context, which includes knowledge of students' culture and background.

Knowledge of the context

In Grossman's (1990) model, knowledge of the context is mainly related to the students and traits and factors, such as age, education, political lives, and social economic background. The teacher's knowledge of these and similar factors will affect how they think about, plan, and carry out instruction. Likewise, knowledge of context in this model is also connected to knowledge of the school, the district, and the community. These elements help dictate the atmosphere, expectations, and agendas of administrators, parents, and other community members. In turn, the expectations, agendas, and so on can influence how the teacher teaches.

Rosenberg and Koehler (2015) suggested that knowledge of context can be defined in two distinct ways: that which surrounds the teacher and is independent of and external to him or her, and that which is woven together with the teacher and allows for analysis of how he or she develops knowledge in-context, which is part of a complex system (p. 442). The former suggests that context is constantly around the teacher and that the teacher can develop (over time) knowledge of his/her specific teaching situation. The latter proposes the teacher and his/her practice is part of a complex system, and teaching can only occur within this system, with all factors mutually acting on one another. Both models suggest that the relationships among home, community, and schools are socially constructed, dynamic, and continually restructuring. Knowledge is seen not only as residing personally within the teacher, but also within the community, grounded in settings of learning and teaching.

Teacher beliefs

Kagan (1992) posited that teacher beliefs are connected to SMK and can be strongly related to content areas. Tam (2015) stated that teacher beliefs were a conglomeration of personal knowledge about students, learning, classrooms, and what needs to be taught. In a case study, Briscoe (1991) found that an experienced chemistry teacher shaped much of his teaching based on beliefs that he had established at the onset of his career. Many of these beliefs were tied to what he thought "teaching chemistry looks like" (p. 191). Some research suggests that beliefs, particularly negative attitudes, will persist throughout a career (Sharma & Sokal, 2015). Because of this, beliefs need to be brought to the conscious level, articulated, and examined, if change is to occur (Sharma &

Sokal, 2015; Stuart & Thurlow, 2000). Tam (2015) also maintains that teacher beliefs need to be acknowledged before change can happen. Farrell (2013) posited that teachers need to consider their beliefs through a process of reflecting-on-action, reflecting-in-action, and reflecting-for-action. To this end, Farrell and Ives (2015) showed that reflection on a teacher's beliefs, in conjunction with classroom observation, provided teachers with the opportunity to examine and change discrepancies between belief and classroom practice. Byrd's (2010) study of a young Spanish teacher's beliefs on teaching writing showed that teacher beliefs can be altered, when she recognized a discrepancy in her thoughts about the importance of writing in the classroom and her approach to teaching the skill.

The Present Study

To determine the abilities of excellent special educators, 143 interviews that broadly examined the ideas associated with teaching special education and the preparation of special educators from the points of view of special educators, general classroom teachers, and administrators in the K-12 situation were conducted over a six-year period. Initially, the participants were contacted via email in districts close to the researcher's university in Utah. Soon, participants suggested others who they thought would be interested in taking part in the study. Hence, educators from five other states (i.e., Arizona, California, Hawaii, Idaho, Nevada) also took part in the study, which added depth and dimension to the responses. Interviews were either conducted face-to-face in person or via Skype. Sixty interviews (20 from each group) were randomly selected from the total pool of participants. The number was deemed sufficient to provide a robust set of data (Creswell, 2013). Table 1 shows the demographics of each group. For the present study, one question from the interviews was examined independently, because it tended to cause a greater degree of emotional response than the other questions among all three groups. This study focused on how special educators are perceived by each group. The question that informed the present study was: What sets an excellent special education teacher apart from a good special education teacher?

	Female	Male	Elementary	Secondary
Special education	16	4	13	7
General education	15	5	15	5
Administration	13	7	18	2

Because of the exploratory nature of the study, qualitative research methodology was deemed appropriate. The data were analyzed using a transcendental phenomenological approach that focused more on the description of the lived experiences of the participants (Creswell, 2013). This approach also enabled the researcher to take a fresh perspective on the data as it was analyzed (Moustakas, 1994). As a post-secondary professor and researcher of teacher education, the researcher needed to acknowledge and bracket the experiences of the participants. None of the participants had ever been a student of the researcher. The guiding principle of the study was to examine how various educators describe various dispositions, specifically those that special educators possess and to look at how the expression of these traits potentially influence relationships among teaching professionals. Typical to qualitative research, the data in the present study were analyzed recursively and inductively, implementing a constant comparison method to determine the themes, both general and specific. Using processes of horizontalization and reduction, which are common to phenomenological research, themes were identified from the present data set that provide an “essence of the experience” that described how each group’s experience played out in determining the difference between a good special education teacher and an excellent one (Eddles-Hirsch, 2015, p. 258). In the process of horizontalization, statements related to the descriptions of excellence among the participants were taken from the data and recorded separately. These statements were examined to ensure no repetition or overlap, and any statements found to do so were combined. Finally, the statements were examined again looking for “moment(s) of experience” that could be abstracted and labeled, leaving five themes that manifested themselves from the participants’ responses (Eddles-Hirsch, p. 258). Four of the themes appeared within the context of all the groups’ responses with one being unique to general education teachers.

Results

The following results delineate the major ideas that were expressed through the lived experiences of the participants. In discussing the themes, it must be acknowledged that they are not always mutually exclusive (Harper & de Jong, 2009).

Traits

The first theme that manifested in the data set was a number of traits that respondents used to describe the excellent special educator. These traits and their groupings are found in Figure 1. The traits provided a broad overview of how the whole group, specific groups within the

whole, and various pairings viewed the excellent special educator. In total, 53 traits were identified by the respondents, but only 13 were shared by some of the groupings and only 4 were identified by every group. First, the special educators interviewed provided 26 separate traits with the most common answers being patience (n=10), persistence (6), and compassion (4). General educators identified 12 distinct traits, the most common being communicator (6), involvement (in classrooms) (5), and organized (3). Administrators supplied 16 different answers with patience (5), communicator (5), and being a learner (3) as the most common. At this level of examination, it is clear to see that just fewer than half of the traits identified overlapped within groups. Each group valued several traits differently than their peers.

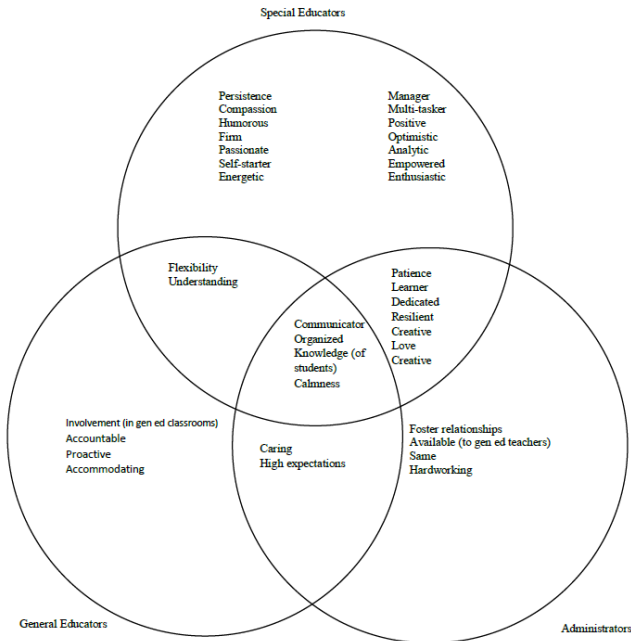


Figure 1: Comparison of traits of the excellent special educator.

When combined, the number of responses also showed some interesting insights. First, special educators and administrators offered five traits that were the same, predominately: patience (n=10/n=5, respectively), being a learner (3/3), and dedicated (2/2). Special and general education teachers only had two traits mentioned by both groups: flexi-

bility (2/2) and understanding (2/1). General educators and administrators had only two traits in common: caring (2/3) and high expectations (2/1). Finally, when all three groups (special educators, general education, and administrators) were considered together, only four traits were common among them: communicator ($n=4/n=5/n=4$, respectively), organized (4/3/1), knowledge (of students) (1/2/2), and calmness (1/2/1).

Of particular concern were the traits that two administrators identified. Both suggested that a teacher is a teacher, regardless of what they teach. The first stated, "special education teachers who are great have the same characteristics as great teachers." The second echoed the sentiment, "I believe that a good teacher is a good teacher, and I don't see a difference in traits." These administrators seemed to be grouping all teachers into a common collective.

Teaching Knowledge

The next theme dealt with specific knowledge that excellent special education teachers possessed. First, the participants spoke of the special educator's ability to know and implement strategies to help the student with special needs. Both the special and general educators stated that the excellent special education teacher "is willing to find the best-fit compensation skills for each situation and then teach them in a method that allows students to be successful." Second, the excellent special educator did not simply know strategies but was willing to find new ways to approach unique situations with students. Two special education interviewees spoke of great special education teachers as being able to "continually search for resources that are updated and new" that allowed them to "present information repetitively in a fresh enthusiastic way." These ideas coincided with statements made by both special educators and administrators, who stated that the excellent special educator must be a "life-long learner," who "stays current in the field" with "a lot of up-to-date knowledge."

An interesting outlier showed itself among the data from special educators and administrators. The former seemed to focus on the idea of "making learning fun" for the students as part of their job, while the latter stated emphatically that excellent special educators "used research-based practices." Although not completely exclusive (i.e., research-based practices can be fun), the lived experience of the two groups showed in how the focus of the two groups can differ.

Relationships

The next theme manifested in the data set was the development of relationships among the various stakeholders in the school. In response

to this question, an administrator stated, “number one is being able to form relationships.” Most often, the data suggested that relationship building occurred when special educators and general education teachers worked together. One general education teacher spoke of the excellent special education teacher she knew by saying, “she did a great job making sure she knew everything going on in the general education classroom so that she could tailor instruction toward that.” Another stated, “one special education teacher was great because she cared about what was happening in the mainstream classroom and they felt like they were a part of our team.” Further, special educators recognized that the relationship was bidirectional, “While she is a resource for others, she recognizes that others are a resource for her.”

Associated with these ideas was a focus on the students as a key part of the relationship. Whereas the general educator above alluded to the notion of tailoring instruction to student, another voiced the opinion that students are key to relationship building more directly, “they took the lead on learning about the student (or students) and proactively offered valuable information about the student.” Another offered this idea in relation to making certain that effective instruction was happening for students with special needs when she said, “they were willing to come into my classroom and work with the student in an environment that would best help them socially.” The groups involved seemed to acknowledge that relationship-building needs to meet the needs academically and otherwise for the student. Finally, a special educator emphasized the point when she stated, “I’ve seen a lot of SPED teachers that don’t make it through their first year because they can’t collaborate or work with people and then they feel like they are getting attacked.”

The Student

The final theme common to all three groups of respondents was one of knowing the student. For administrators, the excellent special educator’s abilities “relate directly to knowing and understanding the student.” Both the special and the general educators elaborated more specifically in this area. For the former group, they described teachers who, “know what triggers your children and what concepts and strategies work and which don’t,” as well as being able to “look at the students’ abilities and not the disabilities.” The latter group described excellent teachers by saying of them, “the difference was that this guy in particular really knew his students,” and “she always made sure to know what her students needed individually, and she made quality behavior plans for students who were struggling with behavior management.” Both sets of teachers actively acknowledged that knowing students was key and were able to

cite specific examples of teachers who could use the knowledge to make a difference.

No Excellence

The last theme in the data came from comments made by the general educators only. Whereas the special education teachers were able to identify at least one specific individual who excelled and did so with some enthusiasm, six of the general education teachers expressed that they did not know a special education teacher who was excellent. Two general education teachers stated that they were still new to the profession and had only worked with one or two special educators in their career. The first acknowledged that excellent special education teachers existed by stating, "I don't know if I ever had. Not because they're not out there, but the only interactions I've ever had with a special education teacher is in a 504 and IEP [specialized education plans]." The second simply indicated, "No, I have not. I've talked to our special ed teacher and bounced ideas off of her, but I haven't worked with her in depth." Because these individuals indicated that they were new to the profession, this reaction is not a surprise. The other four, however, provided a different view either by their negatively toned statement or by qualifying their response. One teacher simply stated, "I don't know one," while another indicated that "I have struggled to be very happy with most of them." The other two qualified their answers by suggesting, "I've only worked with one special ed teacher in my whole teaching career, and I would consider her average" and "I don't know, because I've only worked with two special ed teachers, and they both seemed good."

Discussion

The results of this study suggested that the various participant groups tended to view the idea of the excellent special educator in some unique ways. The findings both unique and common between and among groups is telling but not surprising. To become a teacher, each group followed a specific path through their TPP, and these paths do not always cross, potentially causing a situation where knowledge is not shared about the specifics of each field (Ingvarson et al., 2014; Rock et al., 2016). The literature is replete with studies that indicate that general educators do not feel adequately prepared to teach students with special needs and this finding supports that idea (cf. Berry, 2010; Bruggink et al., 2015; Romi & Leyser, 2006; U.S. Department of Education, 2012; Vitelli, 2015). Likewise, the fact that special educators were able to generate a significantly higher number of traits than the other two groups is important. This might be an indication that special educators are more

familiar with excellent special educators, but it can also be that the general educators and administrators are not seeing or even looking for this high quality in special education positions. Another possibility is that the general educators who do not know an excellent special educator may be stating that special educators are not meeting their perceived needs, at least not at a memorable level. These findings support former research that suggest that there is still a gap in the relationships of special and general educators in the school (Bruggink et al., 2015; Frederickson et al., 2004; Jones et al., 2013).

The findings, especially those found in the traits, are wonderful indicators of teacher beliefs and support former outcomes. The fact that many of the answers provided by the participants varied supported the idea that learning and experience shape perceptions in the classroom (Briscoe, 1991; Tam, 2015). The findings also supported the belief that some negative attitudes can be found among professionals (Sharma & Sokal, 2015). Perhaps through voicing their beliefs, teachers can begin the process of examining those beliefs and adjust as needed (Byrd, 2010; Sharma & Sokal, 2015; Tam, 2015).

The results in the study also showed that each group did not focus on specific SMK of the excellent special educator. Grossman's (1990) cornerstones of GPK, PCK, and knowledge of context greatly overshadowed SMK. All groups focused on knowledge related to the factors on interaction between and among the stakeholders, especially those that benefited the student. Although special educators are prepared to teach any number of content area subjects, such knowledge was not a factor for any of the groups. These findings support Rosenberg and Koehler's (2015) notion that teaching is part of a complex system where teacher and teaching mutually act on each other.

Finally, two related findings that are extremely important are the concepts that the excellent special educator is 1) an effective communicator and 2) able to build relationships. These results support many of the other findings within the study. In other words, when the excellent special education teacher possesses these two characteristics or abilities, he or she is more likely to be able to accomplish the important tasks and actions that were identified in the study, such as becoming familiar with students and their needs. These findings support research that states that building relationships among stakeholders is key for success in both the special and general education environments (Forte & Flores, 2014; Jones et al., 2013; Pellegrino et al., 2015). Since special education teachers are the people who manage case files and are required by law to report data to others, good communication can be viewed as an expectation. However, as one special education participant pointed out, communication needs to be carried out by more than just the special education teacher.

One key to success is to acknowledge the reality that effective communication is not necessarily a natural predisposition for all teachers (Forte & Flores, 2014). Opportunities to learn how to implement effective communication and relationship development requires dedicated time and space for all involved. Much of this initiative needs to be handled by administrators, who often can provide the time, resources, and guidance to help all players optimize their interactions. Troublesome here were the statements of the administrators who thought that the traits possessed by any teacher also qualified a special educator to stand out as excellent. This finding echoes those of Harper and de Jong (2009), who point out that the lack of clearly identifiable traits of excellence can lead to the reliance of static, generic ideas of teaching that fail to meet the needs of both the teacher and student. If the administrators are not seeing a difference in teacher abilities and knowledge, they may not provide the needed support for effective collaboration between the teachers, such as time, place, and resources (Forte & Flores, 2014).

Conclusion

Varied knowledge and skills among educators are needed commodities for student achievement. With the mandate for the LRE in which to teach students with special needs and the current goals that drive inclusive education, effective interactions among educators is vital to achieve an environment where all students can thrive within this model. The findings of the present study suggest that not all educators had the shared, lived experiences to be able to recognize abilities and traits of the excellent special educator.

Griangreco (1997) posited that a shared framework is a key aspect of the successful inclusive school situation. Likewise, collaboration does not happen simply because educators wish it to be so. Effective collaboration takes time and effort. The findings in the present study suggested that not all educators have taken advantage of or been provided with either or both. However, as special and general educators each have specific teacher knowledge, the sharing of knowledge must be encouraged. Both types of teachers may have insights that can inform the inclusive classroom and school context.

Further, TPPs and administrators who provide professional development courses can create meaningful opportunities that allow all groups to interact with each other to establish a habit of collaboration to foster effective inclusion. Likewise, both groups need to be placed into situations where they are required to collaborate with practicing teachers, both special and general education educators. As Bruggink et al. (2015) suggested, teachers and teacher candidates need “exposure in time to the

many situations in which students need additional support, the application of possible measures to meet these needs, and getting advice from colleagues and specialised professionals” (p. 9). Teaching collaborative techniques early will create a more interactive atmosphere, as teacher candidates grow and develop in the profession.

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A Simple Approach to Evaluate Thermal Conductivity of Solids

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ABSTRACT

This paper is a fourth-generation, ongoing experiment at Southern Utah University to experimentally and analytically evaluate the thermal conductivity of a specific solid and compare the result with the published value. The solid used in this experiment was ultra-high-molecular-weight polyethylene. Multiple tests were performed on this material to prove that results, within 2% of the published value, can be achieved through utilizing an insulated short cylinder with a large diameter. This configuration simplified the evaluation and justified the radial one-dimensional heat transfer analysis. This configuration can also be used to test the thermal conductivity of other circular solids. The background, equipment, cost, assumptions, and results of the various tests are also discussed in this research paper.

INTRODUCTION

Being able to measure the thermal conductivity (k) of solids accurately is immensely important for the study of conduction heat transfer. This allows engineers to calculate heat transferred through solid materials. To calculate k , typically, there are a few assumptions considered. These assumptions are as follows: steady-state system, no energy loss to the environment, and no convection or radiation heat transfer. In a real-life application, steady-state conditions are difficult to reach and require accurate forms of measurement and low parasitic heat loss.

Considering these assumptions, Kramer and Chen used a differential steady-state method in their conduction heat transfer experiment to account for parasitic heat loss, but still gained some error percentages due to radiation [1]. In fall 2015, the heat transfer undergraduate research team at Southern Utah University (SUU) used a $10.5 \times 10.5 \times 0.125$ -in aluminum plate as a conductive medium and a lightbulb as the heat source. This material was chosen to reduce the amount of time the experiment took to reach steady state, but the temperature difference was so small that the experiment was not successful [2]. The heat transfer team from Fall 2016 at SUU used a Hardiebacker cement backer board and resistors as a heat source. The experiment showed relatively small error, but the experiment was not repeated to confirm the results (J.R. Kovar, J.R. Chesney, J. Milla, unpubl.). In Fall 2017, the research team used a similar setup to 2016, but the material chosen was ultra-high-molecular-weight (UHMW) plastic (C. Slader, S. Lee, E. Sandall, A.S. Siahpush, unpubl.). There were significant discrepancies between the theoretical and empirical value used in their comparison. They worked together with a local company who had a thermal conductivity testing machine, and their empirical values very closely resembled the values from the testing apparatus [3]. Figure 1 shows models of the progression of the last four generations of thermal conductivity experiments done here at SUU, and Figure 2 shows actual photos of the testing apparatuses used.

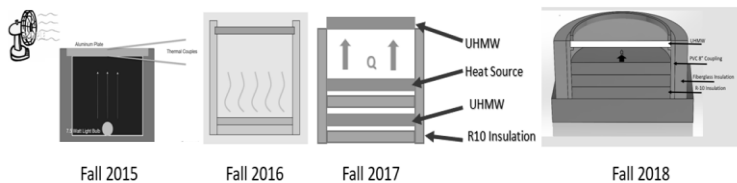


Figure 1. Models of thermal conductivity experiment progression at SUU.

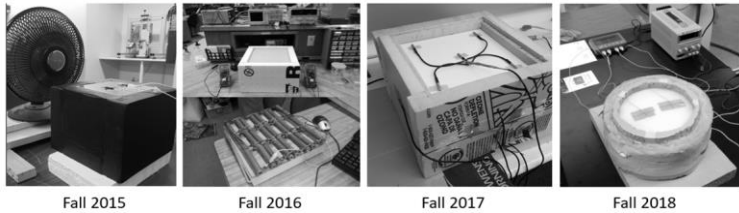


Figure 2. Photos of thermal conductivity experiment progression at SUU.

Apart from the prior research done at SUU, there are several complicated and cost-ineffective methods for undergraduate research to evaluate the thermal conductivity of solid material [4-11] that are beyond the scope and budget of this project and will not be considered.

THEORY

As the second law of thermodynamics indicates, thermal energy moves from higher-temperature substances to lower-temperature ones. When heat is transferred, it occurs in three heat transfer mechanisms: conduction through solids, convection of fluids (liquids or gases), and radiation. The focus of this experiment is to evaluate the thermal conductivity of a solid for steady-state conduction heat transfer. Conduction is defined as “the transfer of energy from the more energetic particles of a substance to the adjacent, less energetic ones as a result of interactions between the particles” [13]. In 1822, French mathematician Jean Baptiste Joseph Fourier derived the equation for the steady-state, one-dimensional conduction heat transfer through a plane wall [1]. His equation is now known as the Fourier’s law of heat conduction and is presented as:

$$\dot{Q} = -KA_c \frac{\Delta T}{\Delta x} \quad (1)$$

where \dot{Q} represents the heat transfer rate (in W), k is the thermal conductivity of the material (in $\frac{W}{m.K}$), ΔT is the change in temperature (in K), Δx is the thickness of the material (in m), and A_c is the cross-sectional area (in m^2). The negative sign in Equation (1) ensures that heat is transferred in the positive x direction and does not violate the second law of thermodynamics. Fourier’s law of heat conduction is the principle equation that will be used to experimentally determine the thermal conductivity of UHMW.

An electrical power supply is being used to generate thermal energy within the resistor heat pads. To calculate the power input, Equation (2) is used,

$$\dot{Q} = VI \quad (2)$$

where in this equation, \dot{Q} is power (W), V is the voltage (V), and I is the current (A). Furthermore, the power calculated (\dot{Q}) in Equation (2), is then substituted in the thermal conductivity (k) equation, Equation (1). \dot{Q} , Δx , and the cross-sectional area (A_c) can be evaluated. Once steady-state is reached by establishing a constant ΔT , k can be calculated by algebraically rearranging Equation (1).

EQUIPMENT

- 8-in PVC pipe coupling
- (2) 45-Watt, 15-volt heat pads
- AZ Instruments 4-channel K-type thermocouple thermometer
- CNC cutting tool to cut 12-in² UHMW to the diameter of the PVC coupling
- Equipment to cut the PVC coupling
- (3) 15-in² rigid foam board insulation
- Fiberglass insulation roll
- DC power supply
- Multimeter
- 12-in² UHMW
- Kapton tape
- Masking tape

COST

The price list shown in Table 1 is based on prices found online. Links are available in the Appendix.

Table 1. Component prices	
ITEM	COST (\$)
Thermocouple thermometer	290
PVC pipe coupling	25
Kapton tape	8
UHMW sheet	25
Foam board insulation	20
Insulation roll	20
Resistor heat pads	20
DC power supply	200
Digital multimeter	30
Total	~650

ASSUMPTIONS

To complete the experiment, certain assumptions must be made. These assumptions include:

1. No convection and radiation occurs inside or outside the system.
2. Once the system reaches steady state, all of the heat (\dot{Q}) from the heat pad resistors will be conducting through the UHMW plane wall plate.
3. One-dimensional conduction heat transfer.
4. No heat transfers through the four pieces of R10 insulation beneath the heat pads.

CONDUCTION HEAT TRANSFER SYSTEM

In the first of the system design, the test apparatus was designed utilizing SolidWorks, a 3D modeling program (http://www.solidworks.com/sw/products/10141_ENU_HTML.htm). This experimental setup is shown in Figure 3. In this figure, \dot{Q} (W) represents the heat transfer rate generated through the heat pads.

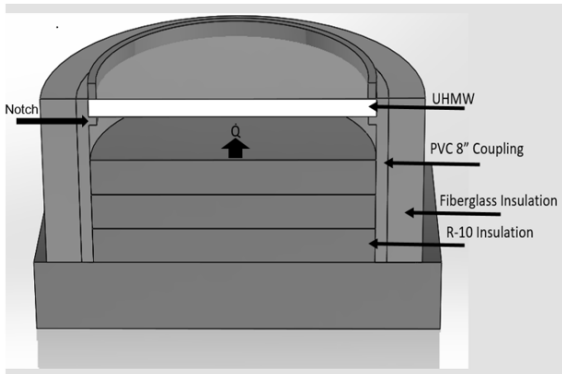


Figure 3. Model of apparatus with UHMW plate, insulation, and PVC.

PROCEDURE

The same procedure was followed for each experimental trial.

1. Cut a piece of insulation to match the same thickness as the notch (see Fig. 3). This configuration will ensure the surface area remains the same as the heat moves from the bottom to the top of the UHMW sample.

2. Cut 3 circular pieces of 1" R10 insulation to fit inside the PVC cylinder.
3. Feed the thermocouples and heat pads through the PVC cylinder from the bottom to the top of the piece.
4. Place the three 1" circular pieces of R10 insulation inside of the PVC cylinder. Note that the UHMW and insulation should be 1" apart to minimize the distance between the material and heat pads and avoid overheating from direct contact.
5. Place 2 thermocouples using the Kapton tape on the internal side of the UHMW piece as shown in Figure 4.

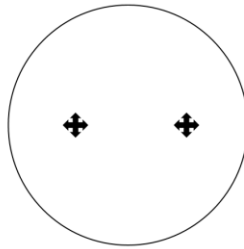


Figure 4. Thermocouple configuration used.

6. Place and tape down 2 heat pads on the R10 insulation.
7. Place the UHMW sample inside of the PVC until it is resting on the PVC notch.
8. Place 2 thermocouples using the Kapton tape on the external side of the UHMW piece as shown in Fig. 4.
9. Attach the piece of insulation cut in Step 1. The insulation piece should be taped down to resemble Fig. 3.
10. Wrap the PVC cylinder with fiberglass insulation; secure it with masking tape. Wear gloves to avoid direct contact with fiberglass.
11. Set the desired voltage on the power supply. Use the digital multimeter (DMM) to measure the current from the power supply. This is done by connecting the DMM in series with the heat pad and power supply shown in Fig. 5.

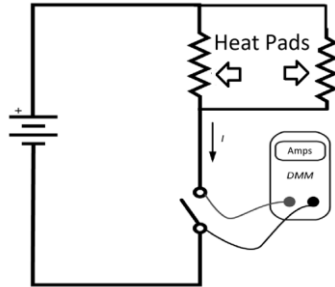


Figure 5. Circuit configuration used to measure current.

12. Remove the DMM and connect the heat pads in parallel to the power supply.
13. Allow the system to reach steady state, then record the change in temperature and calculate the thermal conductivity using Equations (1) and (2). Compare experimental and theoretical thermal conductivity values.

TRIAL ONE

Figure 6 shows the internal configuration of the heat pads, insulation, and thermocouples used for all experimental trials. Once the UHMW plastic cylinder was inserted into the PVC, the entire setup was set on 1-in R10 insulation. To further reduce parasitic heat loss, the PVC was wrapped in fiberglass insulation as seen in Figure 7. The voltage was set to 8 V, and the current was measured with the DMM to be 1.198 A. Using Equation 2, the power from the resistor heat pads was calculated to be 9.584 W. Trial one reached steady state in 7.5 hours.

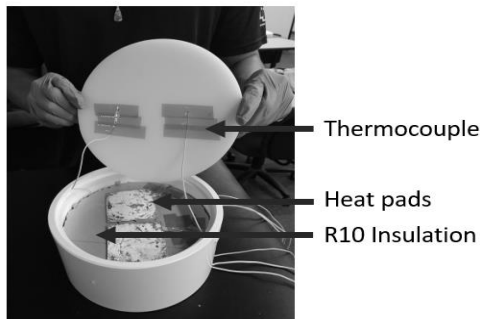


Figure 6. Internal experimental configuration.



Figure 7. External experimental configuration for trial one.

Results

Table 2 shows the data collected from the experiment. This includes the average temperature between the thermocouples on each side of the UHMW plastic, as well as the percent error based on the published value $0.421 \frac{W}{m.K}$ [13]. Figure 8 shows the trends of temperatures on the inside and outside of the apparatus. The data collected showed a significant temperature difference across the plastic.

Table 2. Results from trial one					
Q (W)	ΔT (°C)	Δx (m)	Area (m ²)	k (W/m.K)	% Error
9.584	-18.6	0.0127	0.0285	0.230	45.4

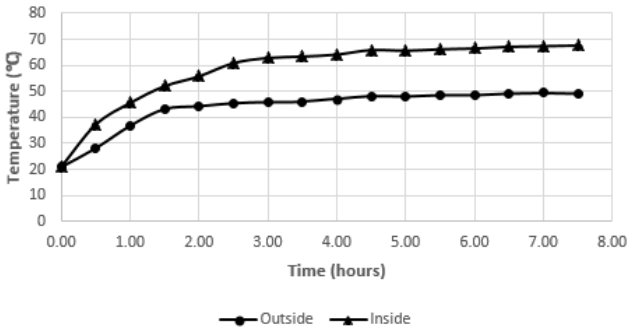


Figure 8. Trial one temperature vs. time in UHMW.

Discussion

The high percent error could be due to the setup of the apparatus. As shown in Figure 7, the fiberglass insulation was used to minimize the natural convection on the top of the plastic. However, the insulation trapped the heat, causing the system to overheat. This overheating caused the inner insulation to melt as shown in Figure 9. As a result, there could be some heat loss from the insulation melting. To avoid overheating in future trials, the fiberglass should be cut to match the height of the PVC cylinder. Furthermore, the temperatures collected from the experiment were recorded every 30 minutes. Although the temperatures were not recorded more frequently, the overall trend of the graph in Figure 8 shows the increase in temperatures. These temperatures eventually plateaued after 4 hours, indicating the system started to reach steady state. The system continued to run for 3 more hours to ensure that the steady-state conditions were obtained. In the next trial, a device should be used to record the different temperatures more frequently to verify the overall trends of the system reaching steady state.

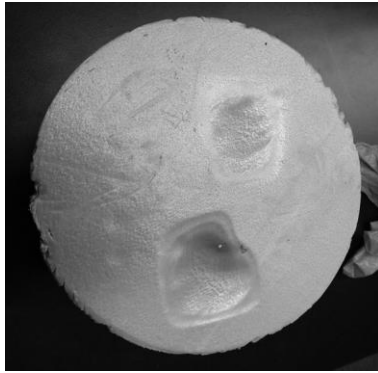


Figure 9. Melting damage on the R10 insulation from trial one.

TRIAL TWO

Figure 10 shows the external experimental configuration for the second trial. The identical internal configuration from trial one was implemented. To increase the accuracy of the calculations and data, certain changes were discussed and implemented in trial two. These changes included cutting the fiberglass insulation to the height of the PVC cylinder, placing 2 in R10 insulation under the PVC cylinder, and reducing the voltage and current to 6.5 V and 0.972 A, respectively. A further discus-

sion of the effects of these alterations is presented in the discussion section. Using Equation (2), the power from the resistor heat pads was calculated to be 6.318 W. Trial two reached steady state in approximately 7 hours.

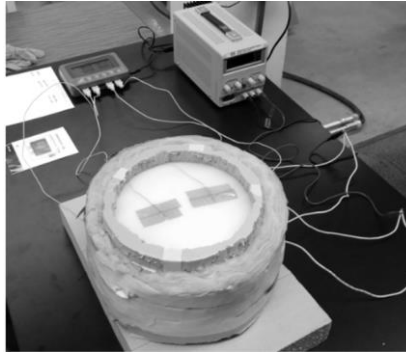


Figure 10. External experimental configuration for trial two.

Results

Table 3 shows the data collected from the experiment. This includes the average temperature between the thermocouples on each side of the UHMW plastic, as well as the percent error based on the published value $0.421 \frac{W}{m.K}$ [12]. Furthermore, Fig. 11 shows the trends of temperatures on the inside and outside of the apparatus using a recording device. The data collected showed a moderate temperature difference across the plastic.

Table 3. Results from trial two					
Q (W)	ΔT (°C)	Δx (m)	Area (m²)	k (W/m.K)	% Error
6.318	-6.0	0.0127	0.0285	0.469	11.4

Discussion

Although the error percentage was not as significant as the first trial, the high power rate may have contributed to the error percentage found in this trial. This could be due to the difference in external temperature of the sample and the room temperature. This high external temperature may have caused additional natural convection, which was not accounted for. Additionally, there may have been parasitic heat loss due to the high internal temperature. As a result, more heat could have been

lost through the PVC and insulation material. During experimentation, the thermocouple failed to record temperature data for the first 2 hours of testing. Although the temperature was not recorded, this had no effect on the steady-state condition of the system.

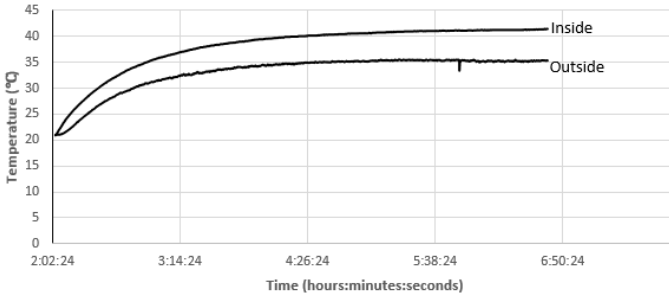


Figure 11. Trial two temperature vs. time in UHMW.

TRIAL THREE

A third trial was conducted with the same experimental configuration as trial two to test whether a reduction of electrical power would decrease the percentage error of the empirical thermal conductivity value. The voltage was reduced to 4.0 V, and the current was measured at 0.599 A. Using Equation (2), the power from the resistor heat pads was calculated to be 2.40 W. Trial three reached steady state in 6 hours. To ensure the repeatability of the experiment, the identical setup was tested 2 more times.

Results

Table 4 shows the data collected from the experiment. This includes the average temperature between the thermocouples on each side of the UHMW plastic, as well as the percent error based on the published value $0.421 \frac{W}{m.K}$ [13]. Furthermore, Figure 12 shows the trends of temperatures on the inside and outside of the apparatus. The data collected showed an adequate temperature difference across the plastic disk.

Table 4. Results from trial three						
Test	Q (W)	ΔT (°C)	Δx (m)	Area (m ²)	k (W/m*K)	% Error
1	2.40	-2.55	0.0127	0.0285	0.419	0.475
2	2.42	-2.55	0.0127	0.0285	0.423	0.475
3	2.40	-2.5	0.0127	0.0285	0.428	1.66

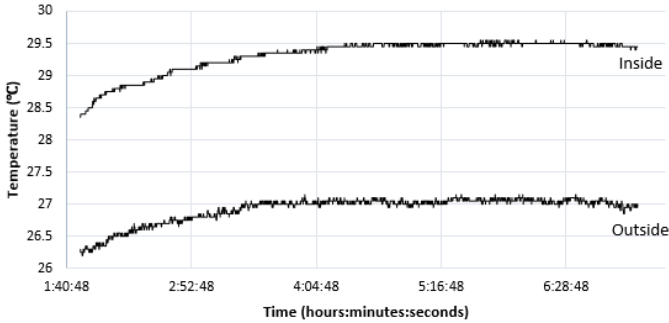


Figure 12. Trial three temperature vs. time in UHMW.

Discussion

The reason for the low error percentage in this trial could be due to the small temperature difference between the outside portion of the sample and room temperature. This small temperature difference minimizes the parasitic heat loss through the PVC and R8 insulation. Even though multiple tests were completed during this trial, only one graph was necessary because of the similar trends when establishing steady-state conditions. Figure 12 shows the data were not collected when the experiment was initiated. Data were collected 2 hours after the experiment was initiated, but the overall trend shows an increase in temperature and eventually plateauing. Steady-state conditions can be observed at 4 hours, as the temperature began to plateau. The experiment was then run for an additional 3 hours to ensure steady-state conditions were achieved. The slight fluctuation shown in Figure 12 is due to the small time interval between recording temperature, which was recorded each second of the experiment.

SOURCES OF ERROR

Throughout each trial of the experiment, there were various reasons for error. These include parasitic heat loss, obtaining one-dimensional steady-state conditions, instrumentation, and material impurities. Parasitic heat loss occurs because of the inability to create a perfect insulation seal to eliminate all heat loss. Parasitic heat loss can be minimized but is impossible to eradicate. To minimize parasitic heat loss, the power input was carefully selected to reduce the difference between the external plastic and room temperatures. This contributes to the majority of the error percentage. In addition, obtaining one-dimensional steady-state conditions is extremely difficult because of the three-dimensional world. This

accounts for a portion of the error because perfect steady-state conditions (100%) cannot be achieved in reality. Because the material thickness is much smaller than its diameter, the one-dimensional assumption is valid. Although not significant, material impurities may have caused an additional error. When the UHMW sample was made, there could have been impurities, air pockets, or other attributes that could have slightly changed the characteristics of the material. This would overall effect the thermal conductivity value, thus creating error within the experiment.

CONCLUSION

One-dimensional, steady-state heat transfer can be used to accurately measure the thermal conductivity of a solid material if the geometry, configuration, power, and material are carefully selected. This is done by establishing steady-state conditions, reducing parasitic heat loss, and applying a uniform heat source. Multiple trials were conducted to verify the results of the experiment. This proves the possibility of successful future attempts to recreate this experiment. The thermal conductivity was calculated within 2% of the published value of the specific material (UHMW). Through a better understanding of heat-transfer principles and energy transfer, engineers can better design systems to effectively transfer energy for desired applications.

RECOMMENDATIONS

For future experimentation, this research could be improved by incorporating a few minor changes. These changes include:

1. Begin testing by reducing input power. When the temperature of the sample and the ambient temperature are reduced, parasitic heat loss is reduced as well.

As long as the change in temperature of the top and bottom of the sample have an average difference of at least 2 degrees, the calculated thermal conductivity value will be satisfactory. At any temperature difference less than 2 degrees, error could be introduced by the variation and inaccuracies of the thermocouple temperature measurement.

2. To increase the validity of the experimental setup and test method, a variety of materials could be tested. Some possible materials for experimentation could include acrylic, glass, or ceramic. To ensure accurate results, if possible, obtain the thermal conductivity value directly from the material manufacturer. This ensures that an incorrect or inaccurate value is not used for comparisons, introducing error into the experiment.

ACKNOWLEDGMENTS

This project would not have been possible without the support of the Department of Engineering and Technology at SUU. The department provided financial support for key pieces of equipment and technical expertise from the professors and instructors.

We would also like to thank the Utah NASA Space Grant Consortium for additional funding and support. In addition, our thanks go to Mr. Greener for obtaining and machining the UHMW piece from Professional Plastics.

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APPENDIX

ITEM	URL
AZ Instruments thermocouple thermometer	https://www.amazon.com/Instruments-Thermometer-Thermocouple-Temperature-K-Thermocouple/dp/B00M9Z3JJ8
PVC pipe coupling	https://www.amazon.com/Spears-Fitting-Coupling-Schedule-Socket/dp/B009F3EOBE/ref=sr_1_2?s=electronics&ie=UTF8&qid=1544472331&sr=8-2&keywords=pvc%2Bpipe%2Bcoupling%2B8%2Binch&th=1
Kapton tape	https://www.amazon.com/Hxtape-Temperature-Polyimide-Printing-Soldering/dp/B07CPP4LBV/ref=sr_1_1_sspa?ie=UTF8&qid=1544472386&sr=8-1-spons&keywords=kapton+tape&psc=1
UHMW sheet	https://www.professionalplastics.com/
Foam board insulation	https://www.homedepot.com/b/Building-Materials-Insulation-Foam-Board-Insulation/N-5yc1vZbaxx?NCN15&searchRedirect=foam+board+insulation&semanticToken=200r20000+%3E++st%3A%7Bfoam+board+insulation%7D%3Ast+cnn%3A%7B0%3A0%7D+ct%3A%7Bfoam+board+insulation%7D%3Act+qu%3A%7Bfoam+board+insulation%7D%3Aq
Fiberglass insulation roll	https://www.homedepot.com/p/Owens-Corning-R-15-Pink-EcoTouch-Kraft-Faced-Fiberglass-Insulation-Roll-15-in-x-24-ft-RF32/205687672
Resistor heat pads	https://www.amazon.com/Adafruit-Electric-Heating-Pad-ADA1481/dp/B00SK6M0AO/ref=sr_1_1?ie=UTF8&qid=1543520527&sr=8-1&keywords=resistor+heat+pad
DC power supply	https://www.gwinstek.com/en-global/products/detail/GPS-Series
Digital multimeter	https://www.amazon.com/s/ref=nb_sb_ss_i_1_12?url=search-alias%3Daps&field-keywords=digital+multimeter&srefix=digital+muil%2Caps%2C186&crd=39SP2QDK1E39X&rh=i%3Aaps%2Ck%3Adigital+multimeter

Heat Transfer Analysis Of Water During Liquid–Solid Phase Change

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Southern Utah University

ABSTRACT

To better understand heat flow through materials undergoing a phase change, experiments were conducted on water during the freezing process. Water was placed in a cylindrical test vessel and cooled from the outer surface of the vessel utilizing a counterflow heat exchanger. The heat exchanger provided constant temperature cooling by means of a constant temperature bath system. The phase change analysis system was designed to promote a phase change (solidification) in the inward radial direction. Because the surface of the water column was partially exposed to the atmosphere, it began to freeze first. However, once the layer of ice on top of the water column reached sufficient thickness, its insulating effect became great enough that the remaining thermocouple data could be calculated as though freezing only occurred in the radial direction, with the top-down aspect being disregarded. As such, the experiment was considered to be one-dimensional heat transfer in the radial direction. The results of the experiment revealed that the heat was transferred in the radial direction in the water below the top surface and that a steady temperature of 0°C was achieved before the water froze. Along with evaluating the freezing process of water, this experiment

verified that the system was operating as intended and that further tests can be performed with eicosane as the phase-change material in future experiments.

INTRODUCTION

During the phase change from liquid to gas, a phenomenon occurs in which the temperature of liquid water does not exceed its boiling temperature. As heat is added to the liquid, any excess thermal energy is consumed in the breaking of intermolecular bonds. This added heat is called the latent heat of vaporization. The temperature of the water molecules can only continue to increase after all of the bonds have been broken and the liquid has completely transformed into vapor.

This constant temperature phenomenon also happens when a liquid changes to a solid. As heat is removed from a liquid, crystal structures form and release heat. This process keeps the temperature constant until all the liquid has turned into a solid. After all of the liquid has transformed, the temperature of the solid is able to drop below the freezing temperature of the material. The total energy removed from a material to change it from a liquid to a solid is known as the latent heat of fusion.

As interest has grown in energy efficiency and sources of clean energy, so has the interest in utilizing the passive thermal energy released or absorbed when material changes phase. Since temperature remains constant during a phase change, phase-changing materials can be used as heat capacitors to maintain a specified temperature (fusion or vaporization temperature) in many different applications. Some examples include the cooling of organs for medical use and passive heating/cooling devices for satellites. A review of the experimental literature [1-8] shows the effort in understanding the behavior of melting or freezing of a phase-change material (PCM) in externally heated or cooled cylinders is an active and ongoing process.

To better understand PCMs, a detailed experimental study was performed to evaluate the heat transfer performance of a liquid to solid phase change energy storage system. The PCM was contained in a vertically oriented test cylinder that was cooled radially inward from its outside boundary (circumference). Cooling was provided by the fluid flow of a constant temperature bath (CTB) system with a counterflow heat exchanger wrapped around the cylindrical test vessel. As the PCM froze, the solid/liquid interface inside the vessel would move radially inward from the inner surface of the vessel, and a thermal resistance layer would be built up by the frozen PCM. This was expected because the solid phase of a PCM has a lower thermal conductivity than the liquid phase.

Accordingly, this ever-thickening solid layer would reduce the heat transfer rate between the CTB and the liquid PCM.

In this undergraduate research experiment, a copper test vessel was filled with deionized water and cooled from 21.5°C (room temperature) to -10°C. During this process, the water completed a phase change from liquid to solid. These tests were performed to evaluate the total heat transfer required to complete the phase change and to perform a detailed system operations test. In the freezing case study, a one-dimensional mathematical model was developed to display the rate of freezing in the radial direction, which considered conduction as the only mode of heat transfer. Additionally, a comparison of experimental data with analytical predictions of the solid/liquid interface position and temperature distribution was performed.

TEST VESSEL SYSTEM

The cylindrical test vessel in Figure 1 contained the water for the experiment. Figure 1 also displays the cooling tubes in contact with the vessel. The cooling tubes allowed the coolant to flow around the vessel and cool the water in the vessel. Additionally, two parallel tubes were wrapped around the vessel providing a counter flow heat exchanger that cooled the vessel uniformly.



Figure 1. Copper vessel with copper tubing wrapped in a helical arrangement.

The temperature of the water in the vessel was monitored using the thermocouple (TC) tree shown in Figure 2. The TCe tree was placed inside the cylindrical test vessel such that the center of the tree was aligned with the vertical central axis of the cylindrical test vessel. Ten thermocouples were used on each row, and there were 9 rows of thermocouples.

The temperature at each point was recorded at 60-second intervals utilizing the data acquisition system. An illustration of the thermocouple tree showing the relative location of each thermocouple is presented in the Appendix.

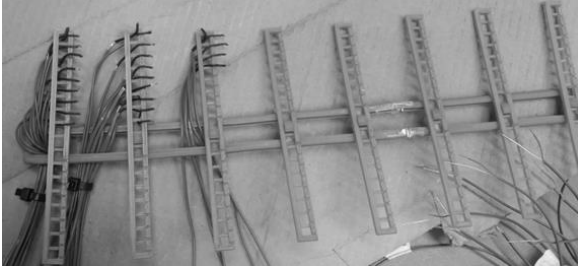


Figure 2. Thermocouple tree used to measure water temperature.

The vessel, coolant tubes, thermocouple tree, piping, and CTB were assembled as shown in Figure 3. In this figure, the insulation was removed to present the system clearly.

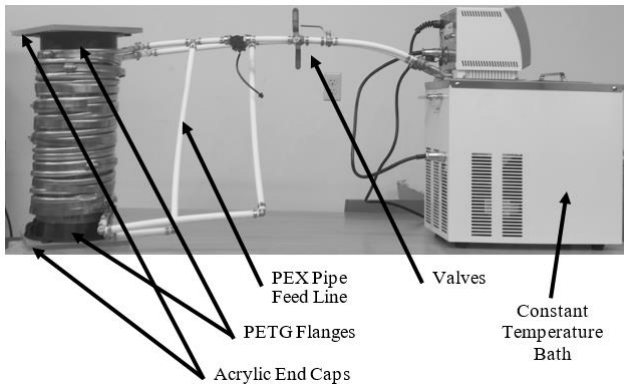


Figure 3. Experimental setup.

RESULTS AND DISCUSSION

Table 1 shows the mass and specific heat of the components of the system. The mass of each component was measured before the experiment. All values were used in the calculation of the final results.

Table 1. Mass and specific heat of components		
Components	Specific heat (kJ/kg·K)	Mass (kg)
Copper vessel	0.377 [9]	3.230
Copper tubing	0.377 [9]	4.820
Acrylic	1.460 [10]	1.280
PETG flanges	1.300 [11]	0.480
PEX tube	2.300 [12]	0.241

PETG, polyethylene terephthalate; PEX, cross-linked polyethylene

Table 2 shows the specific heat, density, mass, and heat of fusion for the working fluid of the CTB, water, and ice. The mass of each component was measured several times before the experiment, and the average was used in the analysis.

Table 2. Thermal properties of working fluid and water/ice				
Components	Specific heat (kJ/kg·K)	Density (kg/m³)	Mass (kg)	Heat of fusion (kJ/kg)
CTB fluid	1.46 [13]	9.70 [13]	N/A	N/A
Water	4.81 [11]	1000 [9]	7.5	333.55 [9]
Ice	2.108 [11]	917 [9]	7.5	333.55 [9]

Figures 4–7 display the temperature recorded by the thermocouples within the test vessel. The top row includes thermocouples in the inward positions A1, A2, B1, B2, C1, C2, D1, D2, E1, and E2, respectively. The second row from the top includes thermocouples in positions A3, A4, B3, B4, C3, C4, D3, D4, E3, and E4, respectively. The lower rows continue the arrangement described.

The initial slopes of Figures 4–7 are steep as they approach temperature of -3°C at approximately 940 seconds (16 minutes). This dip below the freezing temperature was the result of super-cooling before nucleation. After the start of nucleation, the temperature raised to 0°C , at which point, the temperature of the innermost column of water remained constant from 1000 seconds (17 minutes) to 7000 seconds (2 hours). The temperature raised from -3°C to 0°C as a result of heat being expelled as crystal bonds were formed in the water. Once all the liquid water had turned into ice, the temperature of the solid decreased to the final set temperature of -10°C .

Figure 4 shows the temperature change recorded by the third row of thermocouples within the test vessel. This row includes the thermocouples in positions A6, A7, B6, B7, C6, C7, D6, D7, E6, and E7, from outside to inside, respectively.

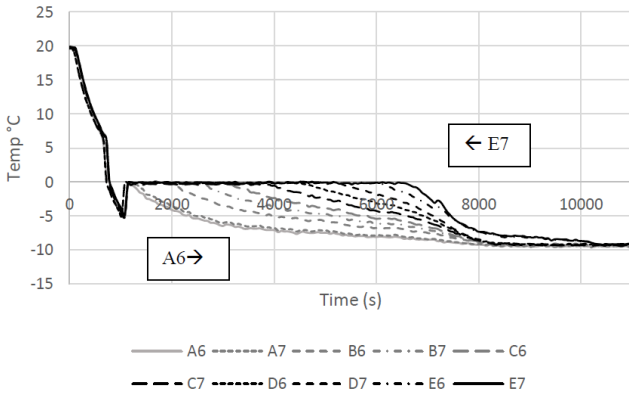


Figure 4. Temperature change of the third (from the top) TC row in the vessel over time.

Figure 4 indicates that each column typically lost temperature quickly in the beginning of the test, super-cooled, stabilized at 0°C , and then finally lowered to -10°C . Because the thermocouples reached a steady temperature of 0°C , temperature of fusion was observed to be 0°C . The time at which a column froze was observed by the sudden drop in temperature below 0°C . At this point, the release of latent phase change energy had ceased, and the water became ice and began to reduce in temperature. This behavior displayed that the thermally capacitive nature of water may be utilized to provide a constant temperature, because the innermost column of water stayed at 0°C for approximately 1.4 hours (span at 0°C) before finally completing phase change.

Figure 5 displays the average temperatures of each column of water over time. The initial temperature started at 21.5°C and reached a final temperature of approximately -10°C . After the initial super-cooling, some columns of water dropped below the freezing temperature sooner than the other columns. The time at which the respective column dropped below the steady-state temperature indicated the time that the column was considered frozen. The columns of water closest to the walls of the vessel froze first, and the freezing propagated radially inward. It was also noted that each column appeared to reach a steady temperature of about -1.8°C . This was due to the top layer of water freezing quickly and beginning to cool as ice. Because of the temperature differential caused by nonhomogeneous phases, the *average* temperature of each column during fusion was slightly below 0°C .

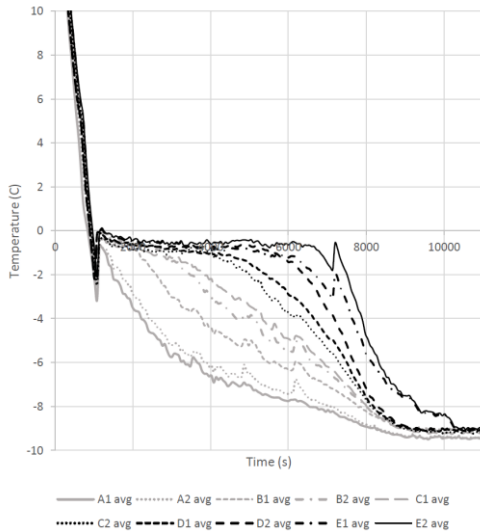


Figure 5. Average temperature of each column of water over time.

Figure 6 shows the calculated radius of fusion. The radius of fusion was found using temperature data from Figure 5. Analysis of the individual TC temperatures report showed the average temperature of a column was -1.8°C , at steady state. As discussed above, this low average temperature was due to the fact that a layer of ice formed on top of the water column early in the test. If the data from the top two rows of TCs were excluded, the average steady state temperature was approximately -0.2°C . The value was slightly less than 0°C because of the noise associated with TC output and data acquisition system uncertainty. Because the location of each thermocouple was known, the radius of fusion was measured by recording the time at which the average temperature of a given column reached -0.2°C . The position of that column was then recorded as the radius of fusion at the given time. To perform the necessary calculations, the points were plotted as can be seen in Figure 6. Linear regression was used to find an equation describing the behavior of the plot. The plot shows the radius of water from the center of the vessel to the outside surface of the vessel (3-in. radius). This figure shows the radius decreasing over time as the water freezes radially inward. The radius equation found from the analysis of the plot was used in determining the mass of liquid water and the mass of the frozen ice as a function of time. The masses were needed to calculate the heat of fusion change over time, as well as the quantities of sensible heat removed. Once the mass was

found, the amount of energy needed to be removed for freezing could be evaluated.

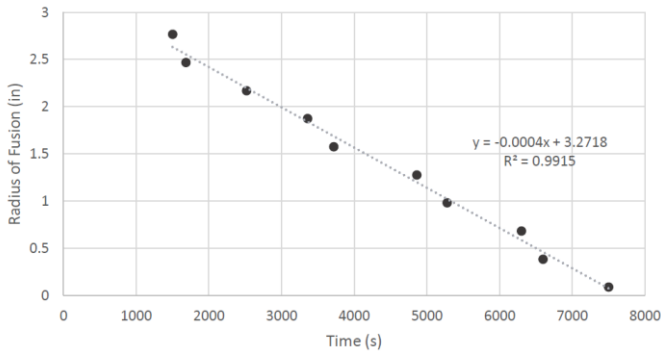


Figure 6. Calculated radius of fusion for ice propagation.

HEAT TRANSFER ANALYSIS

In the freezing process, to simplify the analysis, the following assumptions were made.

- No convection or radiation heat transfer in the solid and liquid.
- One-dimensional heat transfer in the radial (r) direction.
- Physical properties are independent of temperature but different for each phase.
- Overall volume change due to phase change is negligible.
- The solid–liquid interface is clearly defined, i.e., the PCM has a well-defined fusion temperature (no “mushy” interface).
- No heat source or generation.

In a freezing experiment with initial liquid superheat and final solid subcooling, there are four contributions to the total heat transfer at any time: (1) latent heat released by freezing (Q_{fus}); (2) sensible heat released by subcooling of the frozen solid below the fusion temperature (Q_{f-s}); (3) sensible heat released from the superheated liquid that eventually freezes to cool it to the fusion temperature (Q_{l-f}); and (4) sensible heat released from the liquid that remains unfrozen at the time of interest (Q_{sen}). These four contributions are described in detail below.

If m_s (kg) is the mass of frozen water at any time and Δh_{fus} (kJ/kg) is the latent heat of fusion released by the freezing process, then the total heat of fusion (kJ) released is given by [14]:

$$Q_{fus} = m_s \Delta h_{fus} \quad (1)$$

The second component of energy extracted from the water, Q_{f-s} , is given by [14]:

$$Q_{f-s} = m_s c_{ps}(T_{fus} - T_m) \quad (2)$$

where c_{ps} is the solid-phase-specific heat (kJ/kg.K), T_{fus} (°C) is the fusion temperature, and T_m (°C) is the mean temperature of the frozen mass at the end of the data run. The T_m is then expressed as [15]:

$$T_m = \frac{\int_{r_{fus}}^{r_w} T(r)\rho_s 2\pi r dr}{\int_{r_{fus}}^{r_w} \rho_s 2\pi r dr} = \frac{\int_{r_{fus}}^{r_w} T(r)r dr}{\frac{1}{2}(r_w^2 - r_{fus}^2)} \quad (3)$$

The range of the integration is from the solid-liquid interface radius, r_{fus} (m), to the outer tank radius, r_w (m), and ρ_{sol} (kg/m³) is the density of the solid phase.

The local radial temperature in the solid, $T(r)$, was evaluated by postulating a quasi-steady model and solving the energy equation [15]:

$$\frac{d}{dr} \left(d \left(\frac{k_s r dT}{dr} \right) \right) = 0 \quad (4)$$

where k_s is the solid thermal conductivity (W/m·°C). This equation is subjected to the boundary conditions $T = T_{fus}$ at $r = r_{fus}$ and $T = T_w$ (tank wall temperature) at $r = r_w$. Solving Equation (4) for $T(r)$ yields

$$T(r) = \frac{T_w - T_{fus}}{\ln(r_w) - \ln(r_{fus})} \ln \left(\frac{r}{r_{fus}} \right) + T_{fus} \quad (5)$$

Substituting Equation (5) into Equation (3) and then integrating Equation (3) yields the mean temperature of the solid water:

$$T_m = \frac{(T_w - T_{fus})r_w^2}{r_w^2 - r_{fus}^2} - \frac{T_w - T_{fus}}{2(\ln(r_w) - \ln(r_{fus}))} + T_{fus} \quad (6)$$

To evaluate the mean temperature of the frozen mass, from Figure 6, linear regression was used to obtain an equation describing the radius of fusion as a function of time. The radius of fusion evaluated from the analysis of the plot was used to determine the mean temperature of the frozen mass at any time during freezing.

The temperature-dependent specific heat of liquid water $c_{pl}(T)$ (kJ/kg·K) is based on the correlation given by Hale and O'Neill [15] as

$$c_{pl} = 2.0395 + 0.004539T \quad (7)$$

The final energy component, Q_{sen} , is the sensible heat released from the liquid, which remains unfrozen at the time of interest [14]:

$$Q_{sen} = m_l \int_{T_b}^{t_i} c_{pl}(T) dT \quad (8)$$

where m_1 (kg) is the unfrozen water left at end of the test run, and T_b ($^{\circ}\text{C}$) is the bulk temperature of residual liquid. For sufficiently long times, the liquid bulk temperature becomes equal to the fusion temperature. In this case,

$$Q_{1-f} + Q_{\text{sen}} = m_{\text{tot}} \int_{T_{\text{fus}}}^{T_i} c_{\text{pl}}(T) dT \quad (9)$$

where m_{tot} is the total water mass in the tank (kg). From Equations (1), (2), and (9), the total heat transfer from water, Q_{water} , is defined as

$$Q_{\text{water}} = Q_{\text{fusion}} + Q_{f-s} + Q_{1-f} + Q_{\text{sen}} \quad (10)$$

Using the technique mentioned earlier, the heat extracted from the system components could be estimated from the thermocouple data at any time.

The total heat transfer for each component may be expressed as

$$Q_1 = m_{\text{comp}} c_p (T_f - T_i) \quad (11)$$

where Q_1 is the heat transfer (J) to/from a component, m_{comp} is the mass of the component (kg), c_p is the component specific heat (kJ/kg·K), T_f is the temperature of the given component at the time in question ($^{\circ}\text{C}$), and T_i is the initial temperature of the component ($^{\circ}\text{C}$).

The amount of heat removed from the system by each component was determined by monitoring the temperature of each component using thermocouples. The initial temperature remained constant whereas T_f varied as time proceeded. The varied T_f at a specific time indicated the total amount of heat removed by the component at that moment.

Figure 7 shows the amount of heat removed from the system by the CTB fluid compared with the calculated heat removed from components and water within the vessel. The heat removed by the CTB fluid was based on the temperature difference between the inlet and outlet of CTB. The heat removed from the water and components was based on the temperature reported by the thermocouples.

The incremental heat transfer (Q_2) from the cooling system was determined by finding the inlet and outlet temperatures of the CTB fluid for a given time step. The incremental heat transfer (Q_2) from the system to the CTB fluid for a given time step is given by the product of the instantaneous heat transfer and change in the time:

$$Q_2 = \Sigma \dot{m} c_p (\Delta T) \Delta t \quad (12)$$

where \dot{m} is the mass flow rate of CTB fluid in the tubes (kg/sec), c_p is

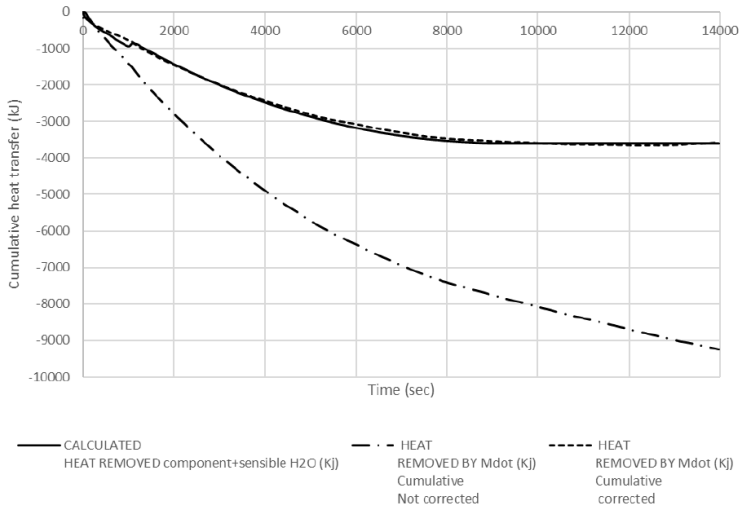


Figure 7. Cumulative heat removed by working fluid and system.

the specific heat of the CTB fluid ($\text{kJ/kg}\cdot\text{K}$), ΔT is the instantaneous temperature difference between the inlet and outlet flow ($^{\circ}\text{C}$), and Δt is the time step (sec). At every time step, the heat transfer from the CTB flow was calculated. At the end of the test run, they were added up to evaluate the cumulative integral heat transfer.

If there is no parasitic heat loss to environment, the energy added to the CTB fluid, Q_2 , is equal to the energy removed from components, Q_1 , plus the energy removed from water, Q_{water} . Using the radius of fusion, the rate of mass change from water to ice could be evaluated. At any interval of time, the mass of ice was then used in the calculations the total energy change of the water/ice in the vessel. The total energy removed from the system is shown in Figure 7.

Figure 7 shows that the heat removed by the CTB fluid, Q_2 was significantly higher than the heat removed from the water. A correction factor was necessary to correct the error due to parasitic heat loss. The correction factor was found by noting the difference between the heat change of the working fluid and the heat change of the system. The difference was plotted over time and given a trend line. This trend line equation was then added to the heat change of the working fluid to produce the corrected \dot{m} plot on Figure 7. It can be seen that this correction produced a very similar trend to the heat change of the system. The heat removed by \dot{m} plot in Figure 7 shows a steep slope indicating that the initial amount of energy removed was large until the slope flattens out

once the system approached steady state. The slope of the CTB fluid does not completely flatten like the water within the vessel but continues to become increasingly negative, indicating there was parasitic heat transfer from the environment. As the system continued to run, \dot{m} absorbed thermal energy from the environment, increasing its cumulative heat removed as seen in Figure 7.

During the heat transfer calculations of the working fluid, a \dot{m} value of 0.4675 kg/s [13] was used. This value was calculated using the expected output of 30 lpm from the CTB.

CONCLUSION

A detailed experiment was conducted to evaluate the performance of a thermal energy storage system utilizing de-ionized water as a PCM. These tests were performed to evaluate the total heat transfer required to complete the phase change and to perform a detailed system operations test. In the freezing case study, a one-dimensional mathematical model was developed to display the rate of freezing in the radial direction, which considered conduction as the only mode of heat transfer. Additionally, a comparison of experimental data with analytical predictions of the solid/liquid interface position and temperature distribution was performed. The temperature analysis revealed that the top surface of the water froze first, indicating heat transfer in the vertical direction. However, once the layer of ice on top of the water column reached sufficient thickness, the insulating properties of the ice became great enough that the remaining thermocouple data could be calculated as though freezing only occurred in the radial direction. As such, the experiment was considered to be one-dimensional heat transfer in the radial direction. The results of the analysis also revealed that a steady temperature of 0°C was achieved before the water froze. Along with evaluating the freezing process of water, temperature measurements in this experiment verified the analytical results. By conducting these experiments with deionized water, future experiments will have a reference on which to base the findings. The validation of the system is important for eicosane testing because eicosane is a much more expensive and much less-documented medium.

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APPENDIX. GRAPHICAL REPRESENTATION OF THERMOCOUPLE ARRAY

A 2	A 3	B 2	B 3	C 2	C 3	D 2	D 3	E 2	E 3	center of cylinder
A 4	A 5	B 4	B 5	C 4	C 5	D 4	D 5	E 4	E 5	
A 6	A 7	B 6	B 7	C 6	C 7	D 6	D 7	E 6	E 7	
A 8	A 9	B 8	B 9	C 8	C 9	D 8	D 9	E 8	E 9	
A 10	A 11	B 10	B 11	C 10	C 11	D 10	D 11	E 10	E 11	
A 12	A 13	B 12	B 13	C 12	C 13	D 12	D 13	E 12	E 13	
A 14	A 15	B 14	B 15	C 14	C 15	D 14	D 15	E 14	E 15	
A 16	A 17	B 16	B 17	C 16	C 17	D 16	D 17	E 16	E 17	
A 18	A 19	B 18	B 19	C 18	C 19	D 18	D 19	E 18	E 19	

Accurately Measuring the Thermal Conductivity of Air: Part 2

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ABSTRACT

Josef Stefan was a 19th-century scientist who was well known for his work in heat transfer. With the use of his apparatus, the diathermometer, he was the first to experimentally evaluate the thermal conductivity of air. With this research performed at Southern Utah University, the work of Josef Stefan was advanced through the building of and experimentation with diathermometers. By submerging diathermometers in an ice-water bath and measuring the pressure and temperature over time, the thermal conductivity of air can be determined. For this experiment, three diathermometers were designed and constructed, and several tests were performed. The data collected from the diathermometers were analyzed to evaluate the thermal conductivity of air. Finally, the results were compared with the published values of the thermal conductivity of air as a function of temperature. The results had some consistent error when compared with published values. This suggests a systematic error.

INTRODUCTION

The purpose of this experiment was to measure the thermal conductivity (k) of air with the use of a diathermometer. The motivation behind performing this experiment was to further improve and expand the work of previous students [1] and have a hands-on heat transfer experience. There is a difference between learning in the classroom and real-world applications. Students from 2017 originally started this project, and this experiment was an improvement of their work. Figure 1 shows a comparison between the diathermometer that the SUU students from 2017 designed and constructed and the one that was designed and constructed by the authors in 2018.

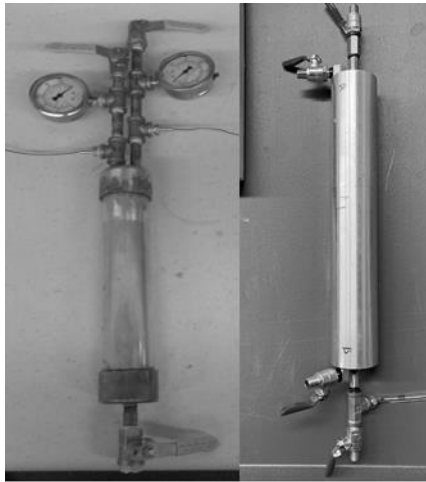


Figure 1. (Left) SUU 2017 design and (right) 2018 design.

While measuring the thermal conductivity (k) of solid materials is a relatively simple process, measuring the k of gases is rather complicated and has baffled many scientists for decades. It was not until 1872 that the thermal conductivity of ideal gases was evaluated experimentally by Josef Stefan, who was able to experimentally evaluate the thermal conductivity of gases with a device he designed and built called the diathermometer. In his first experiment with the diathermometer, his results yielded an error of 11% [2]. A diathermometer is constructed of two concentric cylinders placed very close together (approximately 1.55 mm apart) so that the convection heat transfer may be considered negligible. This configuration permits experimenters to study only conduction heat transfer. This makes measuring the thermal conductivity of ideal gases

possible. In 1984, Strnad and Vengar furthered the research of Stefan by adapting the diathermometer to make it easier for others to reproduce [3]. Their plans were rather difficult to follow though, so an original design was made for this experiment. In 2008, Crepeau published a paper on the contributions that Stefan made to heat transfer [2]. The research from these papers was used to replicate and expand what Stefan originally did in his experiment.

Here we are expanding the scope of the work done by Stefan and by Strnad and Vengar. Three diathermometers of a unique design were produced. Several tests utilizing the diathermometers were performed to verify and validate Stefan's work on measuring the k of air. The diathermometers were constructed such that future experiments may be performed to evaluate the k of other ideal gases using this same process.

DIATHERMOMETER DESIGN

The diathermometers were designed and constructed following similar designs to those of Stefan [1]. For his diathermometer, he used two concentric brass cylinders that only made contact through the inlet and outlet of the center tube. The diathermometer made in this experiment were constructed from two concentric aluminum cylinders that were in contact by a brass inlet and outlet on each end. The researchers chose aluminum for the tubes because it is twice as conductive of heat as brass and is more cost effective.

Parts List

The materials listed were used to make three diathermometers and are presented in Table 1. This excludes any tools/machinery needed to machine/assemble the diathermometers. The materials are split into two different sections: raw aluminum bar stock and finished brass fittings. The materials were purchased from amazon.com and onlinemetals.com.

Machining the Diathermometers

The diathermometers were machined from the raw aluminum bar stock in a machine shop. They were machined to the specifications outlined by the blueprints outlined in the Appendix. Table 2 outlines the different pieces delivered by the machine shop, and Table 3 outlines each mass of the delivered pieces.

Table 1. Materials used to construct 3 diathermometers	
Part	Quantity
Ball valve $\frac{1}{8}$ NPT male-male	12
Nipple $\frac{1}{8}$ NPT 2" long	6
Street 90 $\frac{1}{8}$ NPT male-female	6
All female T $\frac{1}{8}$ NPT	3
$\frac{1}{8}$ barb to $\frac{1}{8}$ NPT female	3
Coupler $\frac{1}{8}$ NPT female-female	3
Aluminum 6061-T6 extruded tube 2.000" OD \times 0.125" wall \times 1.750" ID	36"
Aluminum 6061-T6 extruded tube 1.625" OD \times 0.125" wall \times 1.375" ID	36"
Aluminum 6061-T6 round bar stock 2.000" diameter	6"
Aluminum 6061-T6 round bar stock 1.625" diameter	6"
Quick-set JB-Weld	1

Table 2. Machined parts and quantities to make 3 diathermometers	
Part	Quantity
Large-diameter tube	3
Small-diameter tube	3
Large end cap	6
Small end cap	6

Table 3. List of the mass of each machined component of the diathermometers				
Number of diathermometer, inner/outer tube	Total mass (lbs.)	Mass of tube (lbs.)	Mass of cap A (lbs.)	Mass of cap B (lbs.)
1 Outer	1.00	0.88	0.06	0.06
1 Inner	0.70	0.62	0.04	0.04
2 Outer	1.00	0.88	0.06	0.06
2 Inner	0.72	0.64	0.04	0.04
3 Outer	1.00	0.88	0.06	0.06
3 Inner	0.72	0.64	0.04	0.04

Procedure for Machining

1. Cut the 2" tube into 3 pieces 12" long, and cut the 1.625" tube into 3 pieces 11" long.
2. Thread 4 inches of the 2" round bar stock to (20 TPI), and thread 4 inches of the 1.625 round bar stock to (20 TPI).
3. Thread both ends of each 2" tube and each 1.625" tube to tightly fit its respective threaded round bar stock (Fig. 2).



Figure 2. Threading each tube to fit the threaded bar stock.

4. Cut and face 6 threaded caps off the 2" threaded bar stock and 6 threaded caps off the 1.625" threaded bar stock.
5. Thread the center of the 1.625" caps to 1/8 NPT.
6. Drill the center of the 2" caps so the brass nipple can snugly pass through.
7. Thread the offset hole on the 2" caps to 1/8 NPT.
8. Drill the wrench holes on all 12 caps.
9. Deburr all pieces.

Assembly Procedure

The following is a step-by-step procedure of how to assemble the diathermometer. All the joints were glued with Quick-set JB-Weld. It is recommended to mix the glue in small batches since the working time of the glue is very short.

1. Glue the small caps into the small tubes, and the nipples into the small caps (Fig. 3).



Figure 3. Caps and nipples glued into small tube.

2. Glue 1 large cap into 1 end of the large tubes (Fig. 4).

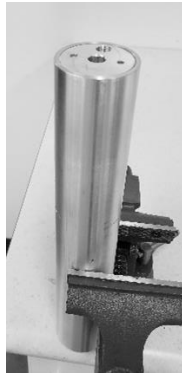


Figure 4. The first large cap glued into the large tube.

3. Glue 1 of the nipples attached to the small tube into the cap glued in the large tube (Fig. 5).

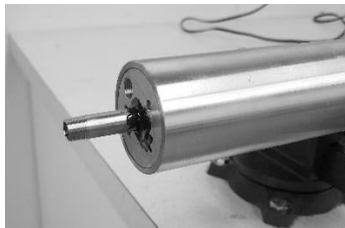


Figure 5. Gluing the small tube into the large tube.

4. Glue the remaining large cap to the open end of the large tube and the nipple of the small tube (Fig. 6).



Figure 6. Gluing the second cap into the diathermometer.

5. Glue a street 90 into each of the large caps. Be sure to orient the 90 facing away from the center of the cap (Fig. 7).

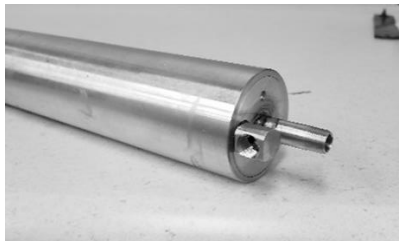


Figure 7. A street 90 glued into the large cap.

6. Glue the 1/8 barb into the perpendicular opening of the “T”.
7. Glue the T on to either of the nipples (Fig. 8).

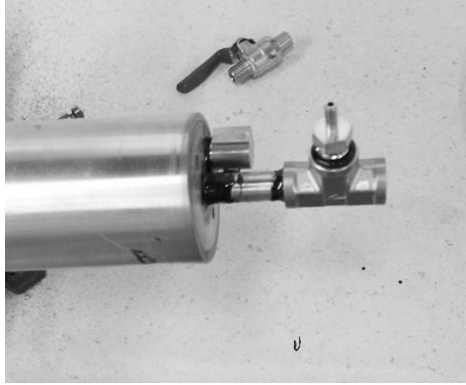


Figure 8. The barb and T glued to one side of the diathermometer.

8. Glue a coupling onto the nipples without a T.
9. Glue a valve onto each available fitting. This will include the: 2 Street 90's, the T, and the coupling (Fig. 9).

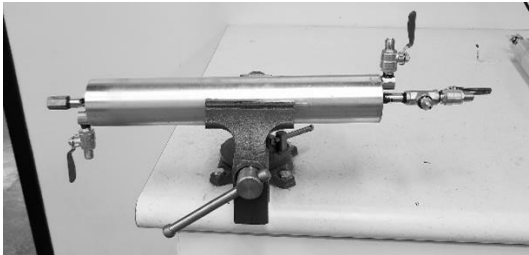


Figure 9. Diathermometer with 3 of the 4 valves glued on.

10. Vacuum testing was then performed to ensure all valves and seals were working properly.

EQUIPMENT LIST

This section presents the list of equipment needed to perform the experiment. See the Machining the Diathermometers section for information on how to construct the diathermometer.

- Diathermometer
- Cooler
- Tubing
- Digital manometer

- Video camera
- Ice
- Water

PROCEDURE

1. Fill the cooler with a sufficient amount of water to fully submerge the diathermometer. Also, add a sufficient amount of ice to get the temperature of the water close to 0°C . Wait until the ice bath temperature is stable (reaching steady state). The water temperature should be approximately 0 to 2°C (Fig. 10).

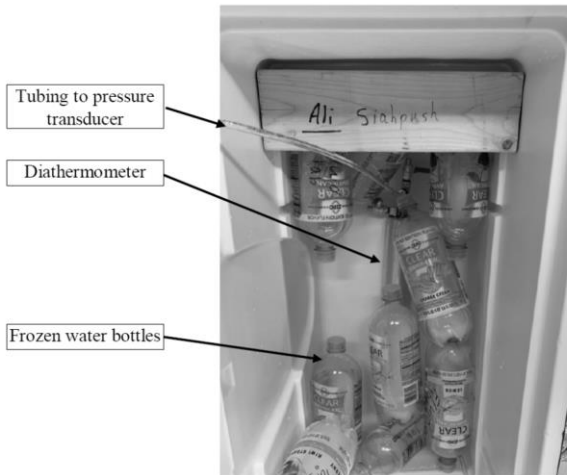


Figure 10. The diathermometer cooling down in the ice-water bath.

2. While waiting for the water to cool down, set up the diathermometer for testing. First, attach the digital manometer to the tube that connects to the diathermometer. Then, close all the valves on the diathermometer to avoid air escaping and create a constant volume process.
3. Set up the video camera so it can record the numbers shown on digital manometer for the length of the experiment. Also, the camera will time stamp the experiment (time vs. pressure).
4. When the water is approximately 0°C begin video recording. Then set the diathermometer into the ice-water bath.

5. Once the pressure on the digital manometer has reached steady state, the experiment is over, and the diathermometer can be taken out of the cooler.
6. Manually enter the data that was recorded from the video camera into Excel.

ANALYSIS

To validate the accuracy of the diathermometer results and to interpret the data obtained by the experiment, the theoretical value of the conductivity of air must first be evaluated. This section provides the calculations done to acquire the results.

For this analysis, the heat transfer is considered one-dimensional (1D). This assumption is valid because the length of the cylinder is much larger than the radius of cylinders and the air gap between the cylinders. It is also assumed that the heat transfer is due to conduction and not due to the natural convection because the air gap (Δx) between cylinders is very small (1.55 mm). Figure 11 shows the diagram of the diathermometer. It includes the outer cylinder, the inner cylinder, and the air gap between the outer and inner cylinder.

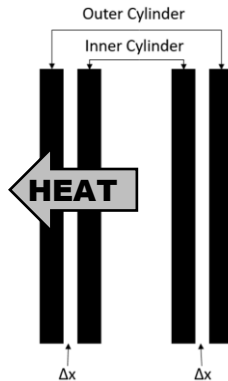


Figure 11. A representation of the diathermometer used in the experiment.

The conduction heat rate transfer in the air between may be expressed as [4]

$$\frac{Q}{\Delta t} = -kA_s \frac{\Delta T}{\Delta x} \quad (1)$$

where k (W/m·K) is the thermal conductivity of air, ΔT is the temperature difference between the inside and outside cylinders ($T_{(t)} - T_f$), and Δx

is the distance between the cylinders as shown in Figure 11. The average surface area of the cylinders (A_s) is presented in Equation (2). In this equation, r_o (in m) is the inner radius of the outside cylinder, L (m) is the height of the cylinders, and r_i (m) is the outer radius of the inside cylinder.

$$A_s = \frac{2\pi r_o L + 2\pi r_i L}{2} \quad (2)$$

The total heat loss, Q (J), in the cylinder is evaluated using Equation (3). In this equation, m (kg) is the mass of the inside cylinder. We are assuming that the mass of air is negligible because it is insignificant when compared with the mass of the cylinder, c (J/kg·K) is the specific heat of the aluminum, T_f (°C) is the final temperature of the inside cylinder, and T_i (°C) is the initial temperature of inside cylinder, which is room temperature.

$$Q = mc(T_f - T_i) \quad (3)$$

If Equation (3) is divided by Δt , then substituted into Eq. (1), then the result is

$$-kA_s \Delta t \frac{\Delta T}{\Delta x} = mc(T_f - T_i) \quad (4)$$

To simplify and for ease of integration, ΔT is replaced by θ , Δt by dt (for a small time interval), then $T_f - T_i$ is expressed as $d\theta$. Thus, Equation (4) takes the form of Equation (7).

$$-kA_s \Delta t \frac{\theta}{\Delta x} = mc \Delta \theta \quad (5)$$

$$G = \frac{-kA_s}{mc \Delta x} \quad (6)$$

$$G * \theta = \frac{d\theta}{dt} \quad (7)$$

Next, reorganized Equation (7) yields

$$\int_0^t dt = \int_{\theta_i}^{\theta(t)} \frac{d\theta}{G * \theta} \quad (8)$$

After integrating, the result is

$$t = \frac{1}{G} * \ln \frac{\theta(t)}{\theta_i} \quad (9)$$

When the aforementioned value of θ and G are substituted into Equation (9), the result is

$$t = \frac{1}{\frac{-kA_s}{mc \Delta x}} * \ln \frac{T(t) - T_o}{T_i - T_o} \quad (10)$$

Because the mass of the inner cylinder is much greater than its contents, the inner cylinder and the air within it will be considered as a single system. This assumption is justified because the temperature of the inner cylinder and the air inside are always the same over time. This assumption allows the use of the Ideal Gas Law to predict the temperature of the inner cylinder and the air inside. From the Ideal Gas Law, the temperature of air can be related to the pressure of the air inside the inside cylinder [4].

$$P = \frac{mR}{V}T \quad (11)$$

Since mass, the R-value (J/kg·K), and volume remain constant throughout the experiment, $\frac{mR}{V}$ can be replaced with a constant. Equation (11) can be used to show the relation between pressure and temperature of an ideal gas. The result is

$$\frac{T(t)-T_o}{T_i-T_o} = \frac{\frac{P(t)}{w} - \frac{P_f}{w}}{\frac{P_i}{w} - \frac{P_f}{w}} = \frac{P(t)-P_f}{P_i-P_f} \quad (12)$$

where T(t) (°C) is the temperature as a function of time, T_o (°C) is the final temperature, T_i (°C) is the initial temperature, P(t) (in psi) is the pressure as a function of time, P_f (psi) is the final pressure, and P_i (psi) is the initial pressure. Substitution of Equations (6) and (12) into Equation (10) yields

$$t = \frac{mc\Delta x}{-kA_s} \ln \frac{P(t)-P_f}{P_i-P_f} \quad (13)$$

Equation (13) may be used to determine the thermal conductivity of air (k). Equation (13) may be rearranged to show the k as a function of time. This is shown in Equation (14).

$$k = \frac{-mc\Delta x}{tA_s} \ln \frac{P(t)-P_f}{P_i-P_f} \quad (14)$$

In Table 4, there is a list of the constant values for some of the variables used in the previous equations.

Table 4. Constant values used in the calculations	
Variable	Value
m	0.29 kg
c	921 J/kg·K [4]
(Average) A _s	0.37623 m ²
Δx	0.00155 m

RESULTS AND DISCUSSION

In the experiment, there were multiple tests performed using an Arduino computing platform [5], but most of the tests were not accurate. The best results were obtained when using a video camera to record the change of pressure versus time. The results are shown in Figure 12, which shows the absolute pressure over the course of time. The general trend appears to be accurate as it is expected that the pressure will drop as time increases. Figure 13 shows how the k values change over time during the experiment. The experimental k values were calculated from the data using Equation (14). It seems there was an error in the calculations because the K value should be decreasing with time instead of increasing. Figure 14 compares the experimental k values to the published k values. In Figure 14, the values for ‘theoretical 1’ were found using the engineering toolbox calculator [6] and the values for ‘theoretical 2’ came from the table “Properties of air at 1 atm pressure” in reference [4].

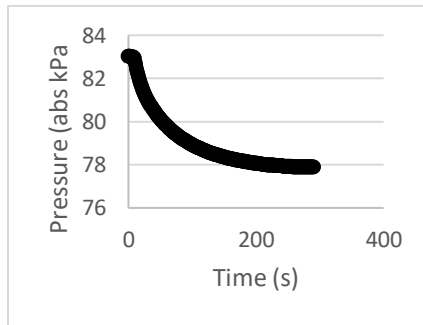


Figure 12. Experimental absolute pressure over time.

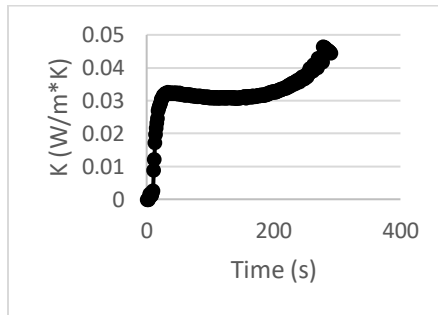


Figure 13. The K value over time.

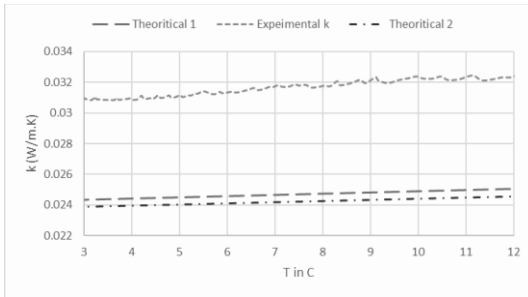


Figure 14. Comparison of theoretical and experimental k over temperature.

The results show that as the absolute pressure dropped the thermal conductivity of air increased. Therefore, it makes sense that the thermal conductivity of air slightly changes with respect to temperature. It was calculated and shown in the Analysis section that this was expected to happen thus, proving the work done by Stefan over 150 years ago. Figure 14 shows the results compared with two different sets of values for the thermal conductivity of air. Both values were included because both were found from reputable sources, and it is unclear which one is the most accurate. While there was some error in this experiment (an analysis of the error can be found in the error analysis section), the results were not far from Stefan's original result for the thermal conductivity. This is significant because, as mentioned before, for years it was accepted that gases could not conduct heat. This research, as well as Stefan's work, prove otherwise. It is also astonishing to think Stefan was able to obtain more accurate results from an experiment done over 150 years ago.

SOURCES OF ERROR

From the data, it is apparent that there was some systematic or instrumentation error. This is seen from all the experimental results being $0.005 \text{ W/m}\cdot\text{K}$ higher than the theoretical results. The average percent error was 16.7%. The consistency of the error suggests that the equipment that was being used was not calibrated correctly or that there was a consistent error in the procedure of the experiment. To determine the type of error, more testing needs to be performed with different instrumentation. The procedure needs to be revised and reviewed to prevent further error from occurring. In addition, a parametric study needs to be performed to determine how sensitive certain variables such as mass, radius, pressure, and gap thickness are to the results.

CONCLUSION

The purpose of this experiment was to perform undergraduate research and advance the work of Stefan, Strnad, and Vengar. The results show that the diathermometers that were built are a reliable, reasonably accurate, and cost-effective approach to determine the thermal conductivity of ideal gases. Although there is some error, that can be attributed to the procedure of the instrumentation that was used; the experiment can still be considered a success, and it proves Stefan's work is accurate.

ACKNOWLEDGMENTS

This project would not have been possible without the support of the Department of Engineering and Technology for financial support for some key pieces of equipment and technical expertise from the professors and instructors in the department. We would also like to thank the Utah NASA Space Grant Consortium for additional funding and support.

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APPENDIX

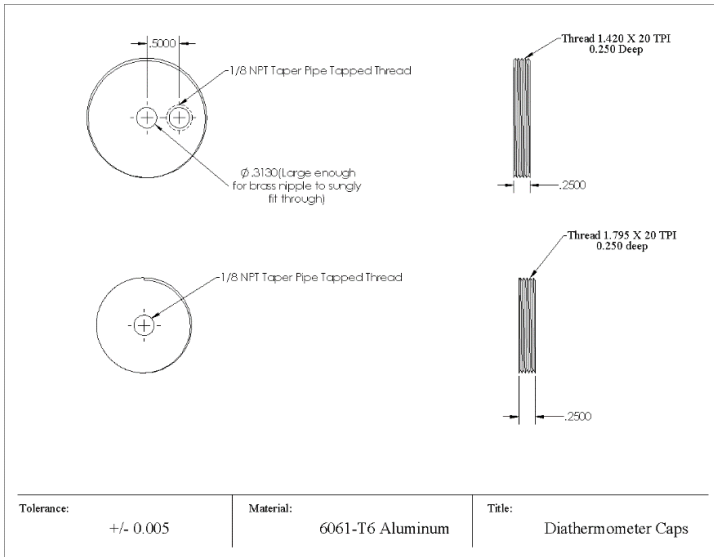


Figure A1. The schematic for the aluminum caps for the diathermometers.

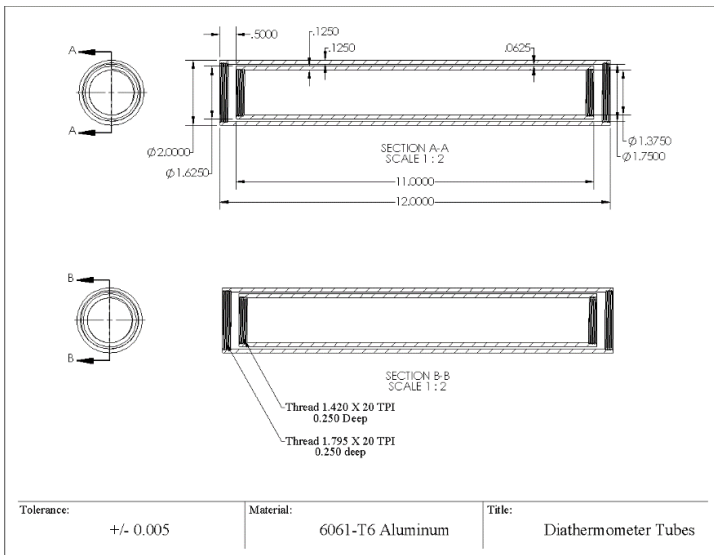


Figure A2. The schematic for the aluminum tubes for the diathermometers.

Applications of Aluminum Foam

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Victoria A. Krull, Ali Siahpush**

Southern Utah University

Summary

Despite a relatively young history, metal foams have had an extensive impact on the industry. With ties to military defense, automobile safety, and jet engine sound dampening, metal foams have been optimized to successfully withstand strenuous circumstances. Applications of metal foams in the industry have led to increased safety, superior mechanical properties, and versatility in recent years. This research paper specifically looks at the sound dampening and energy absorption qualities of aluminum A356 foam, through compression and acoustic testing.

INTRODUCTION

Patents for the manufacturing of metal foams were issued during the 1950s, but most large-scale production did not undergo fruition until the 1980s. Since then, the uses for such versatile materials have been explored more extensively [1]. Some foams have been utilized in fields

such as military defense, sound dampening, and energy-absorbing materials [2]. The porosity and low density of aluminum foam make it particularly useful in these applications.

Considering the characteristics of aluminum foam, specifically, its low density, high heat tolerance, and porosity, the potential for application as a noise dampener in a vehicle that has high heat and emits excessive noise seemed promising. Similarly, the porosity and strength of aluminum foam were signs that it may perform well under compression. In this paper, the acoustic dampening of aluminum foam for jet engine noise and the energy absorption of aluminum foam in the application of automobile crumple points are tested and validated.

NASA has researched the potential of metallic foam in reducing noise created by aircraft. The most promising application is the retrofitting of jet engines with noise-dampening metallic foam liner. While non-metallic foams have been commonly used for effective noise absorption, they can easily combust under the high heat created from an engine. Through NASA's experimentation, metallic foam was discovered to reduce the engine noise significantly without increasing weight or compromising performance [3].

Research has also been performed by the New York Polytechnic School of Engineering on the compressive properties of aluminum foam A356. Two samples of differing densities, referenced as S1 and S2, were studied. Using an Instron 4469 test system [4], three cylindrical specimens of S1 and S2 at 10-mm diameter and 5-mm thickness were tested. The acquired stress–strain relationship is shown in Figure 1 [4]. The area under the stress–strain graph shows the amount of energy absorbed by the material during a compression test.

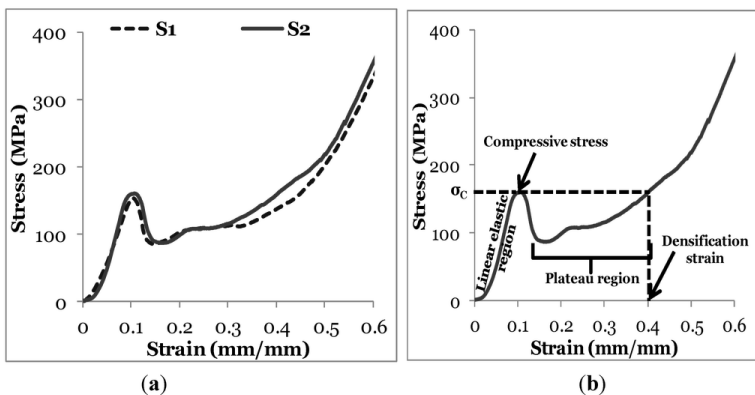


Figure 1. (a) Compressive stress–strain graph of A356 foams; (b) stress–strain curve of S2 specimen [4].

DISCUSSION

Compression Test

Because of its light weight and high-energy absorption, aluminum foam has useful application in the automotive industry. Ford has experimented with aluminum foam and found that a passenger car filled with aluminum foam reinforcement throughout the body provides an improvement of 30% in crash energy absorption at only a 3% weight increase [5]. An increase in energy absorption would directly correspond with a decrease in the force applied to a passenger in a collision. Newton's second law states that force is equal to mass times acceleration.

$$F = ma \quad (1)$$

where F is force (N), m is mass (kg), and a is acceleration (m/s^2)

If a driver is going 50 miles per hour and then hits a brick wall stopping completely, the acceleration will be the change in velocity of 50 miles per hour over the time it takes to stop completely.

$$F = m \cdot \frac{\Delta v}{t} \quad (2)$$

This equation demonstrates that the force exerted on the passengers is inversely proportional to the time it takes to stop the car. If the time is larger, the force of a crash will be reduced and the overall safety of the vehicle is much greater.

At Southern Utah University (SUU), a compression test was performed to test the energy absorption of aluminum foam. Two sheets of aluminum foam were used: one large cell and one small cell (Fig. 2, a and b, respectively). These were purchased from McMaster-Carr for \$27.46 for the small cell 6"×6"×1" sheet and \$21.17 for the large cell of the same dimensions.

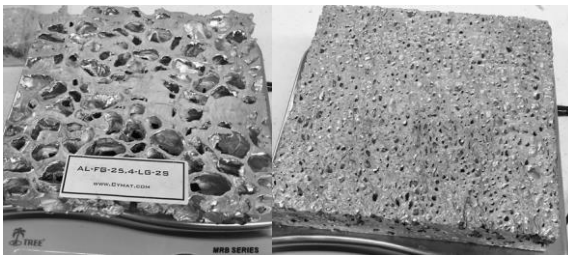


Figure 2. (Left) Large-cell and (right) small-cell A356 aluminum foam.

Smaller samples were cut from these sheets: two of small-cell foam with 1-in³ volume and one of large-cell foam at 1-in² cross-sectional area and 3-in height. A compression apparatus, shown in Figure 3, was used to apply a 1000-lb force on the samples. To measure deformation in inches, force applied, and time, an Arduino board was utilized to record data. This apparatus was constructed by Dr. Bishop (Engineering faculty at SUU) and was made as a proof of concept rather than being as accurate as a professionally manufactured machine; however, it was cost effective and fit within the research budget. The electronics involved in the system can be found in Appendix A. The data gathered includes the time, force, and change in length. These data were used to calculate the stress and strain for the three samples, as displayed in Figure 4a–c.

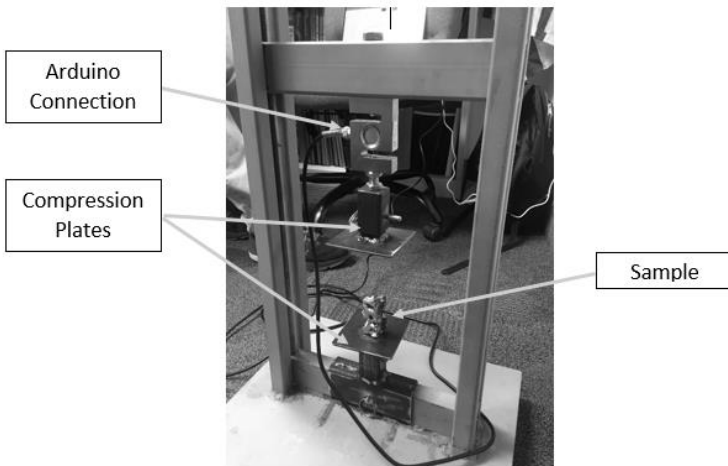


Figure 3. Compression apparatus

In Figure 4, the area under the stress–strain curves was found using Eq. (1) from Appendix B to determine the energy absorption for each sample. Using MatLab, the data collected from the compression test was compiled and the integrals calculated. Table 1 shows the values found. These values indicate the energy that the samples could absorb during compression.

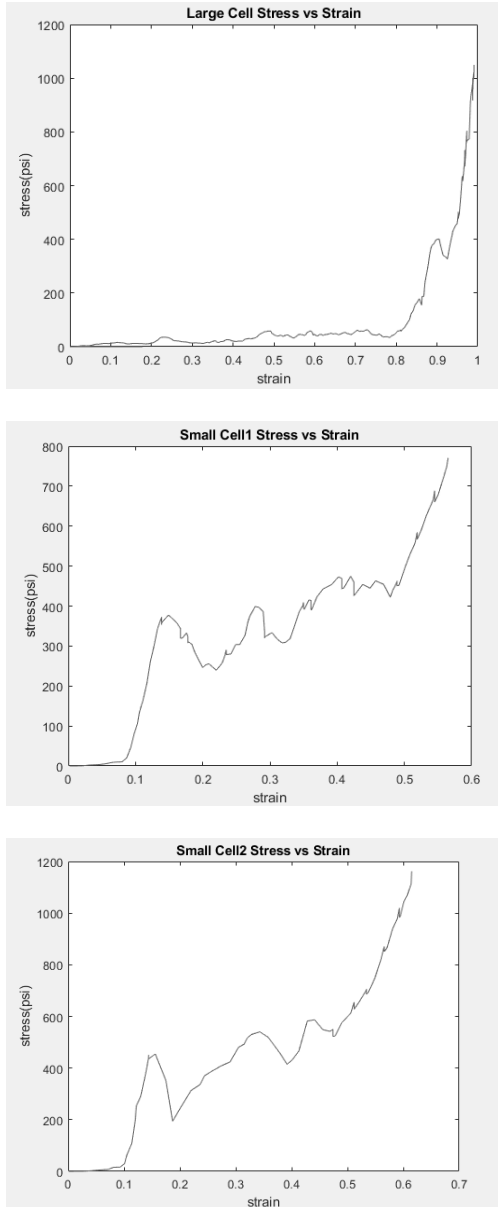


Figure 4. (Top) Large-cell sample, (middle) small-cell sample 1, and (bottom) small-cell 2 stress-strain graphs.

Table 1. Integral values from compression test		
Large Cell	Small Cell 1	Small Cell 2
91.6 psi	186 psi	264 psi

The energy absorption of the large-cell sample is significantly smaller than those from the small-cell samples. The data confirm that the small-cell sample can withstand a larger force with less deformation. This was expected because the large-cell sample has larger pores and therefore has less strength. The units were found to be misleading because psi is a measure of stress, not energy. When taking the integral, the units of stress and strain are multiplied. Stress is in units of lbs/in² and strain is in units of in/in. The resulting units would be in·lbs/in³, demonstrating energy per volume of material.

Volumetric Porosity Test

Using a digital scale, the mass of each sample of aluminum foam was weighed. Then, using the value of density for pure aluminum found in Materials Science and Engineering 9th Edition [6], the porosity was found.

$$\text{Percent Porosity} = \text{volume}_{\text{empty space}} \div \text{volume}_{\text{total}} \quad (3)$$

To find volume of empty space, equation 4 from Appendix B was used.

$$\rho = \frac{\text{mass}}{\text{volume}} \Rightarrow \text{volume}_{\text{mass}} = \frac{\text{mass}}{\rho};$$

$$\text{volume}_{\text{total}} - \text{volume}_{\text{mass}} = \text{volume}_{\text{empty space}} \quad (4)$$

The volume of the mass was determined by rearranging the equation of density to solve for volume. Then, subtracting the volume of aluminum mass from the actual volume of the entire sample will yield the volume of pores. Next, this volume was divided by the total volume to give the volumetric porosity. These values are shown in Table 3.

Table 3. Volumetric porosity test	
Large Cell	Small Cell
95%	84%

The manufacturer reported a density of the small-cell foam of $0.41 \frac{g}{cm^3}$. From the measured mass and volume, the density is calculated to be $0.43 \frac{g}{cm^3}$. With a percent error of 3.7%, this validated the manufacturer's values.

Acoustic Test

An acoustic test was performed to verify the material's sound-dampening properties. To implement the test, a miniDSP (Hong Kong) UMIK-1 microphone reading frequencies between 20 and 20,000 Hz was placed inside an insulated box with one open face. A compressor nozzle pointing 90 degrees from the open face was used to mimic the sound of a jet engine. For each trial, the compressor was run for approximately 20 seconds with different materials covering the open face. The first trial included 2-inch-thick insulation paneling, the second the small-cell foam, the third the large-cell foam. A control sample with no material was also conducted. The acoustic data from the microphone were compiled and compared using Audacity software (Figure 5). The data were plotted in Excel as shown in Figure 6.

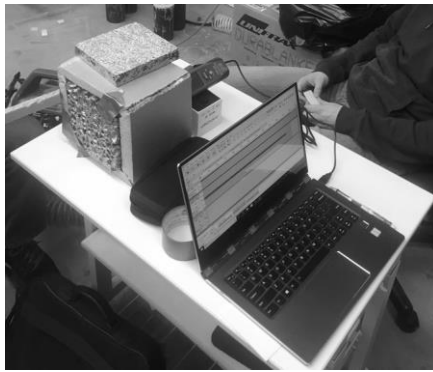


Figure 5. Equipment setup for acoustic testing.

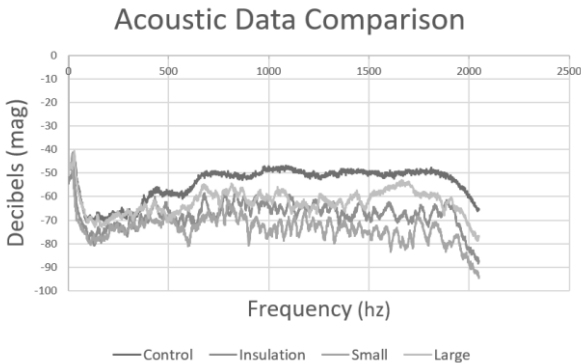


Figure 6. Acoustic test results.

Figure 6 reports data in decibels, but rather than being shown in true values, the decibels are measured in magnitude. Measurements reported in this fashion result in negative values. This is because the highest experienced noise acts as a baseline for the rest of the gathered data. Every point of data will be below this baseline and results in negative values. Therefore, the differences between curves in Figure 9 are the most important principle and not the reported decibels for each sample. The comparison of the acoustic results shows that the 2-in-thick insulation panels and small-cell aluminum foam have the highest noise reduction when compared with the open-faced control. The small-cell aluminum foam creates a difference of approximately 25 dB, and the home insulation only causes a difference of 15 dB compared with the control sample.

Another important note to mention is modes of sound dampening. Mass alone can cause a significant decrease in the intensity of sound. This means that the porosity of the samples may not play as important a role in sound-dampening qualities as originally thought. Despite this, the overall reduction in noise is very satisfactory, and the porosity still plays its role in reducing the overall weight of the metal sample.

Although there are many benefits to using aluminum foam, a major concern for manufacturers is cost. Using Granta software (Cambridge, UK), Figure 7 shows the comparison of price and density for common materials. The sample of aluminum foam used in testing is shown, with a cost around \$150 dollars per ft^3 . Although aluminum foam has a relatively low density, the cost is substantially more than that of many of its competitors.

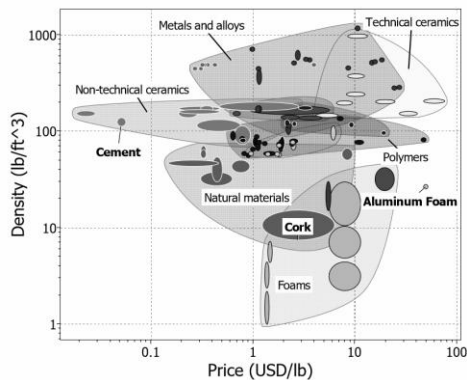


Figure 7. Density vs. price comparison for common materials [7].

Studying Figure 7, a material with similar density to aluminum foam but a much lower cost is cork. Considering cost alone, cork may seem a good alternative to aluminum foam. However, Figure 8 shows that cork has a much lower melting point than aluminum foam. In the application of noise dampening for a jet turbine liner, a low melting point could be detrimental to performance. Although aluminum foam is somewhat expensive, it has a very low density when compared with steel and a similar melting point, making aluminum foam a viable candidate for use in automobiles and planes, where it would perform similarly to steel without the added weight.

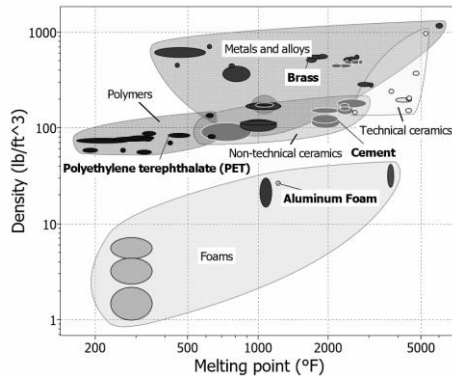


Figure 8. Density vs. melting point comparison for common materials [7].

SOURCES OF ERROR

Errors may have originated from several sources. A main source of error is the compression test samples. Each one had a different cross-sectional area, which may have caused variations in stress calculations, making them less comparable. The compression machine also only had a load capacity of 1,000 lbs, which could change results when comparing with a professional Instron (Norwood, MA) machine.

Another originator of error was found during the acoustic testing. The amplitude of the sound wave would increase or decrease based on the angle toward or away from the microphone. User bias may have changed the angle during the trials, and this would have varied the results during testing. The apparatus surrounding the microphone did not have a mechanism for holding the test specimen in place, and therefore duct tape was used. This may have changed the sound-dampening abilities slightly. There is also the case of environmental noise that would be picked up by the microphone.

Error may be found stemming from the manufacturing of the foam when trying to compare with other values. The specimen under scrutiny was fabricated using a continuous casting process, and air bubbles with a calcium mixture to add viscosity. Variations in the manufacturing will cause error.

Finally, when calculating the porosity of the foam, the density of pure aluminum was used rather than the A356 sample's actual density. To improve accuracy, one could melt down a portion of the foam and then calculate the density with mass and volume measurements.

CONCLUSION

Aluminum A356 foam is a viable option for both sound dampening in high temperatures and also applications in energy absorption. Specifically, applications in jet engine liners and vehicle crumple points were researched and prove promising. The specimen under research withstood 1,000 pounds of force and is able to withstand more, but because of limitations with equipment, the samples were not placed under any further stress. This would be an area of improvement for future testing, because an Instron compression machine could give more insightful results. Sound-dampening tests showed, in comparison to current home insulating foams, aluminum foam exceeded the standard. Adding a comparison to egg crate foam would be a useful test, as it is widely used in the sound-dampening industry today. More testing with a wider variety of frequencies would also provide useful data into the true sound-dampening ability of the aluminum foam. Aluminum foam is a valuable choice in the aforementioned applications.

ACKNOWLEDGMENTS

This project would not have been possible without the support from the Department of Engineering and Technology at Southern Utah University, which provided financial support for some key pieces of equipment. Appreciation is also expressed to the Utah NASA Space Grant Consortium for additional funding and support.

Extra thanks to Dr. Scott Munro and Dr. Jacob Bishop [7] for their technical expertise in acoustics and materials, respectively.

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APPENDIX A

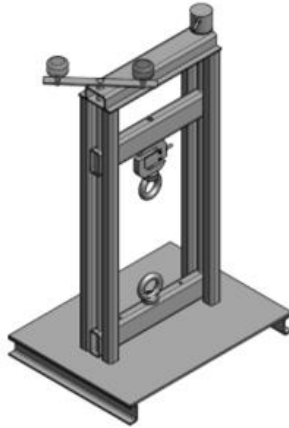


Table 3: Electronics and Instrumentation

Description	Model	Vendor	Price
Raspberry Pi 2	B+	amazon.com	\$39.99
Arduino	Uno R3	amazon.com	\$ 9.99
Optical rotary encoder, 600 p/r	LPA3806-600BM	amazon.com	\$17.99
200 kg s-type load cell	BZLQR	amazon.com	\$42.95
Fused male power socket 10A	IEC320 C14	amazon.com	\$ 4.47
Power cord	IEC320 C13	amazon.com	\$ 6.99
Proto board and wires	IB401	amazon.com	\$ 4.29
16 mm 5-pin aviation connector	GX12-5	amazon.com	\$ 8.90
24-bit A/D module	HX-711	amazon.com	\$ 8.11
Pyle 7 in LCD display	PLHR70	amazon.com	\$22.99
			\$166.67

Figure 10: Image reproduced with permission from Dr. Jacob Bishop’s paper showing electronic components [7]

“The total cost for the materials listed was \$369.75. The cost of the system has important implications on potential applications for this project. The most obvious application for this machine is to increase the ratio of testing equipment to students to the extent that every student or pair of students in a class has the ability to work at their own machine. This is in itself a drastic improvement over the current state of affairs in which only a few students can use a machine in a class period.” [7]

APPENDIX B

Equations

- (1) Integral for Energy Absorption

$$\int_0^{\text{Max } \epsilon} f(\sigma) d\epsilon$$

(2) $\sigma = \frac{\text{Force}}{\text{Area}}, \epsilon = \frac{\Delta \text{Length}}{\text{Length}_i}$

(3) $\rho = \frac{\text{mass}}{\text{volume}} \Rightarrow \text{volume}_{\text{mass}} = \frac{\text{mass}}{\rho},$

$$\text{volume}_{\text{total}} - \text{volume}_{\text{mass}} = \text{volume}_{\text{empty space}},$$

$$\text{Percent Porosity} = \text{volume}_{\text{empty space}} \div \text{volume}_{\text{total}}$$

The Effects of a University Stress Relief Center on Perceived and Physiological Measures of Stress

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Alex Jensen²

¹Weber State University; ²Idaho State University

ABSTRACT

The primary objective of this study was to determine the impact of a university Stress Relief Center in the Midwestern United States on students as measured by blood pressure, heart rate, perception of physical pain, and perception of stress. In September 2009–August 2016, approximately 13,000 students volunteered in using the tools and interventions at a university Stress Relief Center. The results were analyzed using quantitative causal-comparative post hoc and Pearson product correlation methods. Gender, stress management class enrollment, time of participation, tools and interventions, perceived physical pain and stress, blood pressure, and heart rates were analyzed. A significant lowering of perceived physical pain and perceived stress levels occurred after center visits. The Stress Relief Center is a new and successful model that other universities, businesses, communities can use to improve well-being. Stress management education combined with stress management tools and interventions is highly recommended.

Introduction

One of the top health problems for Americans is stress (American Institute of Stress, 2016a). Stress potentially affects everyone regardless of age, sex, gender, race, nationality, or occupation (Selye, 1956), and everyone experiences some degree of stress at some time (Selye, 1956) although in different ways (Kabat-Zinn, 1990; Lazarus & Folkman, 1984; Olpin & Hesson, 2016). If there is a perception of a threat associated with a situation or event, the body naturally activates the stress response (Chao, 2012).

During the stress response, heart rate, respiration rate, metabolism, oxygen consumption, oxygen to the brain, blood pressure, blood sugar, hormone secretion, muscle contraction, cholesterol output, blood clotting ability, blood thinning, pupil dilation, brainwave activity, and sensory awareness are all increased while immune, reproductive, digestive, and excretory performances, blood vessel diameter, and higher-order thinking are decreased (Olpin & Hesson, 2016). Prolonged emotional stress is a contributing factor for severe conditions like heart disease, cancer, clinical depression, cardiovascular disease, human immunodeficiency virus, and cancer (Cohen et al., 2007; Ornish, 1990; Olpin & Hesson, 2016). Anxiety, depression, executive and/or cognitive dysfunction, cardiovascular phenomena, metabolic disorders, atherosclerotic cardiovascular disease, degenerative neurovascular disease, osteopenia, osteoporosis, and sleep disorders can also result from prolonged stress (Chrousos, 2009). Besides these diseases, prolonged stress can cause permanent damage and affect one's whole being (Gunnar & Quevedo, 2007).

College can be a particularly stressful place for young adults (Conley et al., 2013) because of the many roles and demands placed upon them. As the principal advocate and leadership organization for college and university health, the American College Health Association (ACHA) collects data regarding students' habits, behaviors, and perceptions on the most prevalent health topics for the approximately 20 million college students in the United States. Stress ranked as the highest academic impediment at 108 higher education institutions among 93,034 respondents in 2011–2015 (American College Health Association, 2015a). During the college transition time, and throughout the college experience, students have many demands from work, school, and family. With the abundant number of stressors comes uncertainty as many college students are transitioning from adolescence into adulthood (Dyson & Renk, 2006). Stressors affecting college students include self-infliction, conflict, frustration, and pressure (Misra & McKean, 2000). The way students perceive stressors often determines the effect the stressor will have.

Even though the demand for stress relief is high, many universities typically lack the services and interventions to help students cope with stress (Conley et al., 2013). Because of this lack, college students frequently use unhealthy ways of coping (Conley et al., 2013; Lee & Cohn, 2009), and thus, many students may experience higher levels of stress than is healthy or necessary. Two common examples of unhealthy coping are (a) avoidant coping: when students have wishful thinking, self-distraction, denial, mental or behavioral disengagement (Dyson & Renk, 2006; Lee & Cohn, 2009), and (b) emotion-focused coping: when students have maladaptive functioning and experience strain (Dyson & Renk, 2006; Lee & Cohn, 2009). The consequences of dealing with stress in unhealthy ways, combined with stressors, can have a detrimental impact on overall health and academic progress. College students with high levels of stress are at risk of academic difficulties, substance abuse, and emotional problems (Chiauzzi et al., 2008).

On some college campuses, exploring stress management interventions helps students cope with stress effectively. These interventions include seminars (Conley et al., 2013) courses on time management, social networking groups, problem-solving training, fun campus activities (Misra & McKean, 2000), workshops on coping strategies, and peer relationships (Gan et al., 2010). Education about useful stress management strategies and opportunities to practice stress management techniques increase student well-being (King et al., 2012). Emerging practices to improve stress management on college campuses include designated places where students can cope with stress through education and activities (Stress Management and Biofeedback Services, 2016).

Emerging work on practical and inexpensive interventions requires further investigation to implement the most beneficial interventions. The purpose of the present study was to determine the impact of a university Stress Relief Center on students' stress and well-being. The hypothesis is that Stress Relief Centers would improve the overall well-being of college students by decreasing or eliminating stress as measured by perceived and actual physiological measures of stress. Specifically, the following questions were investigated:

1. What effect does a visit to the university Stress Relief Center have on students' perceived stress or physical pain levels and physiological measures of blood pressure and heart rates?
2. Is there a difference in perceived stress or physical pain levels and physiological measures for students enrolled in stress management courses, between male and female students, and between students who spend varying amounts of time in the Stress Relief Center?

3. Is there a relationship between students' perceived stress or physical pain levels and blood pressure?

Methods

We employed a quantitative causal-comparative post hoc method with archived data using paired *t*-tests and Pearson product correlations for analysis. Data consisted of archival information for approximately 13,000 students who used the Stress Relief Center from 2009 to 2016. Blood pressure and resting heart rate were measured using an Omron blood pressure and heart rate machine; a Likert scale was used to self-measure perceived stress and physical pain. Beginning in 2015, students indicated if they were currently enrolled in a stress management class.

Setting

The university Stress Relief Center is located in the Rocky Mountain Region of the United States. Undergraduate and graduate students are mostly white Caucasian. In 2015, students at this university rated stress as the top academic impediment (American Health College Association, 2015b). As all interventions available in the Stress Relief Center are included in student fees, there was no charge to participate in the activities or learn about stress management techniques. Before 2015, data regarding perceived physical pain and student enrollment in a stress management class were not gathered.

Procedure

The typical procedures at this Stress Relief Center included the following activities. A student checks in at the greeting area, gives consent for data use in nonspecified investigations, and gives permission to have his or her blood pressure and heart rate measured. The student then self-rates stress and physical pain levels using a scale of 1–10 (i.e., 1 meaning almost no stress or physical pain and 10 meaning very high stress or physical pain) and discloses year in school and enrollment in a stress management class. After checking in, students can request to use any number of tools or interventions for any amount of time without charge. Tools and interventions include: back massager, bio-feedback, chi machine, essential oils, foot and calf massager, head massager, hot chocolate, iLightz (light and sound machine), inversion table, massage chair, massage mat, herbal tea, Vitamin D light, guided relaxation exercise, relaxing music, reading mind and body wellness books and magazines, and

sitting meditation. Over the years of the study period, tools and interventions have been added or removed. The Stress Relief Center expanded and moved to a new location in 2015.

Immediately after using one or more of the tools or interventions, participants' resting heart rate, blood pressure, stress-related physical pain, and perceived stress are measured again. Archived data over the 7 years were coded for importation into Statistical Package for the Social Sciences (SPSS) and filtered into subcategories for analyses. Paired sample *t*-tests were selected to analyze differences between pre-visit and post-visit perceived stress and physical pain levels, heart rates, and blood pressure rates, as well as differences between the length of visits, sex, and stress management class enrollment. Pearson product correlation tests were used to analyze the relationship between blood pressure and perceived stress and physical pain levels.

Results

The results of this study do not evaluate the effect of the tools or interventions for stress relief but reflect an analysis of a place that provides tools and interventions for stress relief. Results are given by the research question.

A two-tailed paired samples *t*-test revealed that the Stress Relief Center had a positive and significant effect on the well-being of students as determined by perceived and physiological measures. Significant lowering of perceived stress ($t=115.699$; $p\leq 0.001$) and physical pain ($t=38.002$; $p\leq 0.001$), heart rate ($t=41.192$; $p\leq 0.001$), and systolic blood pressure ($t=24.742$; $p\leq 0.001$) occurred after visiting the center (Table 1).

	Pre	Post	MD	SD	T	DF	p-value
Stress level	5.06	2.80	2.260	2.156	115.699	12189	0.000
Pain level	2.63	1.42	1.214	1.830	37.995	3278	0.000
Heart rate	78.81	72.38	6.435	15.731	41.192	10138	0.000
Systolic BP	119.14	114.96	4.174	17.020	24.742	10176	0.000
Diastolic BP	75.34	72.09	3.252	12.646	25.931	10170	0.000

Pre, mean before visit; Post, mean after visit; MD, mean deviation; SD, standard deviation; T, calculated difference in units of standard error; DF, degrees of freedom; BP, blood pressure

Differences in perceived stress, perceived physical pain, blood pressure, and heart rates among students who were enrolled in a stress management class, were female and male, spent varying amounts of time in the center were determined. Data on stress management course enrollment were gathered for 2015–2016. There were 208 students enrolled in stress management classes and 3,894 students not enrolled in such courses (Table 2).

Table 2. Pre- and Post-Visit Measures by Enrollment in a Stress Management Class							
	Pre	Post	MD	SD	T	DF	p-value
Enrollment in a Stress Management Class							
Stress level	4.11	2.03	2.072	1.529	19.545	207	0.000
Pain level	2.26	1.03	1.232	1.595	9.072	137	0.000
Heart rate	75.81	68.4	6.966	9.715	10.317	206	0.000
Systolic BP	112.20	108.67	3.529	9.724	5.234	207	0.000
Diastolic BP	74.47	71.41	3.053	8.648	5.091	207	0.000
Not Enrolled in a Stress Management Class							
Stress level	4.65	2.67	1.983	1.478	83.752	3893	0.000
Pain level	2.63	1.41	1.218	1.834	37.839	3248	0.000
Heart rate	79.06	74.22	4.849	143.312	2.066	3728	0.039
Systolic BP	114.34	110.93	3.410	34.207	6.094	3736	0.000
Diastolic BP	77.02	72.08	4.933	113.833	2.649	3735	0.008

Pre, mean before visit; Post, mean after visit; MD, mean deviation; SD, standard deviation; T, calculated difference in units of standard error; DF, degrees of freedom; BP, blood pressure

Visiting the Stress Relief Center had significant positive effects for all students whether enrolled in a stress management class or not. However, enrolled students had lower levels of self-rated stress ($t=19.545$; $p\leq.0001$) and physical pain ($t=9.072$; $p\leq.0001$) and lower heart ($t=10.317$; $p\leq.0001$) and blood pressure (systolic $t=5.234$; $p\leq.0001$; diastolic $t=5.091$; $p\leq.0001$) rates after visits than non-enrolled students.

Both female and male students experienced significant decreases in stress and physical pain levels, heart rate, and blood pressure after visiting the Stress Relief Center (Table 3). Male students ($n=5768$) had slightly lower perceived pre-visit stress and post-visit stress and pre-visit physical pain and post-visit physical pain levels than females ($n=6383$). Females averaged lower pre-visit systolic blood pressure, higher post-visit systolic blood pressure, higher pre-visit diastolic blood pressure, and higher post-visit diastolic blood pressure, than males (Table 3).

Table 3. Pre- and Post-Visit Measures of Female and Male Students							
	Pre	Post	MD	SD	T	DF	p-value
Females							
Stress level	5.19	2.86	2.323	2.164	85.749	6382	0.000
Pain level	2.89	1.57	1.321	1.782	29.639	1598	0.000
Heart rate	80.27	73.04	7.231	15.984	32.691	5221	0.000
Systolic BP	113.70	111.50	2.203	16.827	9.487	5250	0.000
Diastolic BP	73.93	71.07	2.864	12.735	16.287	5244	0.000
Males							
Stress level	4.911	2.72	2.192	2.147	77.524	5766	0.000
Pain level	2.37	1.27	1.103	1.860	24.192	1662	0.000
Heart rate	77.27	71.67	5.598	15.430	25.339	4877	0.000
Systolic BP	125.00	118.69	6.305	16.996	25.930	4884	0.000
Diastolic BP	76.87	73.17	3.698	12.533	20.611	4880	0.000

Pre, mean before visit; Post, mean after visit; MD, mean deviation; SD, standard deviation; T, calculated difference in units of standard error; DF, degrees of freedom; BP, blood pressure

Students visited the Stress Relief Center for periods of varying duration. Time spent in the center was coded as 15 minutes or less, 30 minutes or less, and 31 minutes or more. The average time students spent in the center was 33 minutes. Students who stayed in the center ≤ 15 minutes ($n=476$) had the highest pre-visit heart rates ($m=79.86$) and the largest lowering in heart rate ($m=7.191$; $t=6.949$ $p\leq.0001$). Additionally, after spending only ≤ 15 minutes in the center, students experienced significant changes in perceived stress ($t=19.752$; $p\leq.0001$) and physical pain level ($t=4.2$; $p\leq.0001$) and heart rate ($t=6.949$; $p\leq.0001$). Students who spent ≤ 30 minutes in the center ($n=7022$) had significant lowering of perceived stress ($t=85.370$; $p\leq.0001$) and physical pain ($t=29.963$; $p\leq.0001$) levels as well as heart rate ($t=30.365$; $p\leq.0001$), and systolic ($t=18.802$; $p\leq.0001$) and diastolic ($t=19.637$; $p\leq.0001$) blood pressure. Students who stayed in the center for ≥ 31 minutes ($n=4471$) had the highest pre-visit perceived and post-perceived stress levels and pre-visit blood pressure rates. Students who spent ≥ 31 minutes in the Stress Relief Center also experienced significant lowering of perceived stress ($t=73.885$; $p\leq.0001$) levels as well as heart rate ($t=26.681$; $p\leq.0001$) and systolic ($t=15.2$; $p\leq.0001$) and diastolic ($t=15.2$; $p\leq.0001$) blood pressure rates (Table 4).

Perceived stress correlated significantly with blood pressure for students both before and after visiting the center. High pre-visit per-

ceived stress was positively correlated with high pre-systolic blood pressure ($n=11452$, $r=0.072$; $p\leq 0.001$), high pre-visit diastolic blood pressure ($n=11459$, $r=0.066$; $p\leq 0.001$), and high pre-visit heart rate ($n=11445$, $r=0.067$; $p\leq 0.001$), and lowered post-visit perceived stress was significantly correlated with post-visit systolic blood pressure ($n=10280$, $r=0.036$; $p\leq 0.001$), post-visit diastolic blood pressure ($n=10280$, $r=0.025$; $p\leq 0.001$), and lowered post-visit heart rate ($n=10251$, $r=0.032$; $p\leq 0.001$).

Table 4. Pre- and Post-Visit Measures for Participants by Time Spent in Center							
	Pre	Post	MD	SD	T	DF	p-value
15 Minutes or Less in the Center							
Stress level	4.84	2.82	2.022	2.233	19.752	475	0.000
Pain level	2.27	1.40	.872	1.833	4.200	77	0.000
Heart rate	79.86	72.67	7.191	17.662	6.949	287	0.000
Systolic BP	117.92	116.16	1.758	19.761	1.523	292	0.129
Diastolic BP	74.19	72.32	1.873	13.138	2.437	291	0.015
30 Minutes or Less in the Center							
Stress level	4.96	2.84	2.123	2.084	85.370	7021	0.000
Pain level	2.57	1.42	1.154	1.758	29.963	2083	0.000
Heart rate	78.68	75.52	6.156	15.528	30.365	5865	0.000
Systolic BP	118.92	114.78	4.137	16.881	18.802	5884	0.000
Diastolic BP	75.23	72.01	3.214	12.545	19.637	5876	0.000
31 Minutes or More in the Center							
Stress level	5.20	2.74	2.461	2.227	73.885	4470	0.000
Pain level	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Heart rate	79.105	72.20	6.904	15.938	26.681	3793	0.000
Systolic BP	119.372	72.21	4.224	17.147	15.200	3805	0.000
Diastolic BP	75.65	72.21	3.444	12.634	15.200	3805	0.000

Pre, mean before visit; Post, mean after visit; MD, mean deviation; SD, standard deviation; T, calculated difference in units of standard error; DF, degrees of freedom; BP, blood pressure

The relationship between perceived physical pain and heart rate was not as consistently uniform as the findings between stress and blood pressure. Pre-visit perceived physical pain was significantly correlated with pre-visit heart rate ($n=3244$, $r=0.50$ $p\leq 0.005$). Similarly, post-visit perceived physical pain had a significant correlation with post-visit heart rate ($n=3143$, $r=0.047$; $p\leq 0.01$).

Discussion

Prior research indicates that because college students experience high levels of stress, education on stress as well as the provision of interventions are needed at universities (Baghurst & Kelley, 2014; Conley et al., 2013; Dinzeo et al., 2013; Giancola et al., 2009; King et al., 2012; Misra & McKean, 2000). College students' well-being is critical to academics and life. In response to the American College Health Association (2015a) report on the prevalence of stress at universities throughout the U.S., the Stress Relief Center introduced an approach to help college students effectively cope with stress as determined by self-rated perceptions of stress and physical pain levels, and measured blood pressure and heart rates. After visiting the Stress Relief Center, significant and positive effects were found alleviating stress and physical pain symptoms for students.

Providing college students with interventions and education on how to use them are two critical factors in increasing student health and overall well-being. The finding that stress levels and physiological measurements of students enrolled in stress management classes are lower than those who are not underscores the importance of education in managing stress. Combining stress management education (Lin & Huang, 2014) with the tools and interventions provided at the Stress Relief Center offers more significant benefits in reduced heart rate and blood pressure than use of center tools and interventions alone.

Slight differences between male and female student levels align with findings by Dyson and Renk (2006) and Pedersen (2012). Higher stress levels in females in this study concur with findings by Pedersen (2012) and Hudd et al. (2000) that female students report experiencing slightly more stress than male students do. Higher participation rates by females in the Stress Relief Center activities may be tied to their higher self-reported rates of stress.

Using the tools and interventions provided at the center had a significant effect on lowering perceived physical pain levels, especially when pre-visit physical pain levels were high. Physical pain relief may not result in stress relief, but stress relief could bring physical pain relief (Ekpenyong et al., 2013). Perceptions of stress can decrease or increase aspects of the stress response.

Irrespective of time spent in the center, a significant lowering of stress levels occurred. Students who spent 15 minutes or less in the center had the highest pre-visit heart rates. Students who spent 31 minutes or more in the center arrived with the highest perceived stress levels. Average times spent in the relief center was 33 minutes. Managing time effectively can reduce stress (Misra & McKean, 2000), and it may be that

students who make the time to visit the center are indeed managing time effectively so they can visit.

That perceived physical pain was significantly correlated with heart rate but not blood pressure is consistent with the findings by Olpin (2010) that during the stress response, the sympathetic branch of the autonomic nervous system increases the heart rate and blood pressure, and the parasympathetic branch of the autonomic nervous system decreases the perception of physical pain.

Recommendations

Establishing a Stress Relief Center is recommended at universities. In affiliation with universities, companies that create stress relief products could provide support and, in return, benefit from centers that use their products. In such an alliance, a synergistic effort in making tools and interventions for stress relief available to more people could result in long-lasting beneficial results. As more stress relief tools and interventions are provided by the market and more education about stress relief is offered by universities, evidence from this current study suggests that stress will be reduced. Future investigations to determine when during the semester students feel the most or least stressed may help guide research that leads to more targeted stress reduction interventions.

Additional analysis of stress perception and its relationship to blood pressure and heart rate is needed. Other tools for testing physiological effects before and after center visits could include electroencephalogram machines to measure brainwaves, pulse oximeters to measure levels of oxygen in the blood, or other devices to measure sweat and saliva.

Conclusion

The Stress Relief Center is a free place for university students to use different tools and interventions for stress relief with no time restrictions. The overall effects of visits to the Stress Relief Center were significant in perceived stress and physical pain levels, blood pressure, and heart rates. Significant improvement was noted for both females and males, for periods of less than 15 minutes to more than 30 minutes, and for students who were or were not enrolled in stress management courses. Such significant finding across all students in various situations provides strong support for continued use of university and business Stress Relief Centers.

Disclosures

Dr. Olpin is the creator and director of the Stress Relief Center.

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The Impact of Exposure to Alcoholism on Children and Adolescents: A Review of the Literature

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Abstract

The purpose of this literature review was to provide a summary of the impact that exposure to alcoholism has on the health and developmental well-being of children and adolescents. A search was conducted to analyze the available literature using keywords “alcoholism,” “children,” “adolescents,” “impact,” and “outcome” to help identify important articles that were pertinent to the topic using the following databases: Academic Search Premier, ERIC, CINAHL Complete, PsycINFO, and MEDLINE. Articles published from 2006 to 2017 were included. Nine articles were selected to compose this literature review. The results revealed that children and adolescents living with alcoholism are at increased risk of experiencing emotional, physical, and sexual abuse; developing emotional and behavioral problems; and facing other negative consequences in their lives. The significant impact can endure even beyond adolescence. The results suggested that efforts should be made to enhance the parenting awareness and capacity. Parents need

guidance on effectively controlling their alcohol consumption and need education to understand the problems associated with protecting the younger generation.

Introduction

Alcoholism is a form of addiction in which the affected individual tends to drink continually without demonstrating any controllable measure to gauge the situation, resulting in unrestrained behavior (Doumas et al., 2015). Alcohol consumption has a direct effect on the user's brain; thus, an alcoholic's judgment and ability to think are often impaired (Marshall, 2014; Vaillant, 2006). Unfortunately, many alcohol abusers are also caretakers of children and adolescents (Solis et al., 2012). As the result, their behavior and well-being have huge impact on younger generations. Parents' excessive alcohol use negatively affects children and adolescents in their care, resulting in serious issues such as domestic violence, child abuse, and neglect (Nodar, 2012).

Research has shown that domestic violence, child abuse, and alcoholism are closely correlated (Vaillant, 2006). Drinking exacerbates problems in a family and turns into violence. Because children and adolescents are so vulnerable, they are usually the primary victims of alcohol-related abuses (Marshall, 2014). Children born and raised in an alcoholic family have a higher risk of abuse compared with children in families that do not indulge in alcohol (Doumas et al., 2015; Nodar, 2012; Lown et al., 2010). Also, in an environment fraught with alcohol abuse, children often witness violence, and because they are not yet able to think critically and independently, these children may develop their own violent tendencies in the future (Doumas et al., 2015).

Alcoholics neglect their parental responsibilities, cannot guide or communicate with family members well, and are unable to properly serve as the head of their family (Doumas et al., 2015). Adults who abuse alcohol do not always value their children as much as they prioritize consumption of their drinks (Johnson & Stone, 2009). As a result, these parents deny their children the opportunity to grow up in a safe and healthy environment (Johnson & Stone, 2009). Children in this home situation feel abandoned, their needs are not met, and their actions are not monitored. Neglected children tend to engage in detrimental activities such as truancy, drug abuse, or other behaviors that can negatively impact their life (Carstairs, 2011). Behaviors such as these can also dramatically impact communities and society at large, as misguided children also influence their peers to engage in the same (Zhang et al., 2012). In severe cases, excessive consumption of alcohol can lead to the death of the user,

leaving the children with either a single parent or no caregiver at all (Vaishnavi et al., 2017). Children who have lost a caregiver to alcoholism must face and cope with many difficulties in their day-to-day routines, making life and survival extremely challenging (Marshall, 2014).

Parents' drinking behavior also affects their children's intentions to use alcohol in the future (Tildesley & Andrews, 2009) as they are simultaneously indulging in alcohol at earlier stages of development (Marshall, 2014; Rangarajan, 2008). According to the National Institute on Alcohol Abuse and Alcoholism, up to 18.2% of alcoholics' children also use alcohol in their future lives (NIAAA, 1999). Several studies also suggest that parent alcohol use problems and abuse have been found to be predictors of early alcohol use for children and adolescents (Tildesley & Andrews, 2009; Wills & Yaeger, 2003).

Given the significant impact of exposure to alcoholism on children and adolescents, it is important to gain a better understanding of it. To date, however, there has been no synthesis of the existing research on this topic. The purpose of this literature review was to provide a summary of the impact that exposure to alcoholism had on the health and developmental well-being of children and adolescents.

Methods

This review involved a comprehensive search of identified databases including Academic Search Premier, ERIC, CINAHL Complete, PsycINFO, and MEDLINE using the keywords "alcoholism," "children," "adolescents," "impact," and "outcome." The search focused on the peer-reviewed scholarly articles published in English from 2006 to 2017. The initial searches captured 68 unique articles. The titles and abstracts were then screened according to the following exclusion criteria: 1) samples not drawn from the U.S.; 2) were unrelated to the issue; and 3) did not use a validated data-based research design. Finally, 9 studies were included in this review.

Findings

All findings are presented as they relate to the three domains: neglect and abuse, parental capacity, and psychological effects. All aspects of interest were investigated and the outcomes were critically examined with a focus on understanding both the impact and consequences felt by children and adolescents exposed to alcoholism. A summary of the 9 identified articles is included in Table 1.

Table 1: Summary of reviewed articles		
Authors (N)	Aims/Objectives of study	Study type; Major findings
Lown et al., 2010 (N=3,680)	To providing a comprehensive description of past year and lifetime alcohol consumption patterns, consequences, and dependence among women reporting either child physical or sexual abuse in a national sample of women.	Quantitative study; Child sexual abuse was significantly associated with past year and lifetime alcohol consumption.
Nodar, 2012 (N=16)	To challenge the belief that adult children of alcoholics tend to abuse alcohol as the result of genetic composition and to show instead evidence that the unpredictable home environment in which alcoholics grow up may be responsible.	Prospective observational study; Alcoholic parents attempt to alter their moods, such as depression, anxiety, anger, and feelings of inadequacy, through alcohol consumption, causing inconsistencies in discipline, nurturance, meals, and general family dysfunction.
Rangarajan, 2008 (N=515)	To examine the effects of parental alcoholism on adult offspring's self-esteem and to identify and test possible mediators and moderators of parental alcoholism effects on the self-esteem of adult offspring.	Quantitative study; Paternal attachment, results once again showed support for the detrimental effects of paternal alcoholism.

Silveri, 2012 (N=104)	To highlight neurobiological evidence indicating the vulnerabilities of the emerging adult brain to alcohol effects and to identify that reduced sensitivity to alcohol sedation and increased sensitivity to alcohol-related disruptions in memory, positive family history of alcoholism effects on brain structure and function, and emerging co-morbid psychiatric conditions serve as unique vulnerabilities that increase the risks associated with underage alcohol use.	Prospective observational study; Heavy alcohol exposure during adolescence is associated with significant deficits in memory retention, producing great cumulative damage and impairments in social, behavioral, and cognitive functioning.
Doumas et al., 2015 (N=205)	To examine maternal and paternal influences on adolescent alcohol use and alcohol-related consequences in a sample of ninth-grade students.	Quantitative study; Parental monitoring, disapproval of teen alcohol use, and quality of parent–kid communication were significant predictors of drinking behaviors.
Johnson & Stone, 2009 (N=813)	To investigate the impact of parental alcoholism and various indices of family functioning on differentiation levels of young adults.	Quantitative study; Parental alcoholism and levels of functioning, as well as certain experiences within alcoholic families, are significantly predictive of differentiation levels of children.
Navarra, 2007 (N=3 couples)	To identify the role family relationships play in alcohol dependence and recovery process.	Qualitative study; Couple and family relationships play a significant role in alcohol dependence and recovery processes.

Galvani, 2006 (N=20)	To (1) question whether women blamed alcohol for their partner's violence, (2) establish whether women made allowances for their partner's violence because of his drinking, (3) determine the extent to which the women believed alcohol played a key role in such violence, and (4) explore any differences in the women's beliefs about alcohol's role in violence when it was directed at others and when it was directed at them.	Qualitative study; Women experienced their partner's drinking as leading to violent and aggressive behavior. The majority of women mentioned preexisting aggression and preexisting worries.
Carstairs, 2011 (N=1)	A case example of a mother who neglected her children is presented using two administrations, one before and one after treatment.	Case study; The mother's social skills are limited, and she may present as helpless, with some insensitivity to the needs of others. She may be conservative in close relationships, she may be cautious about getting close to others, and she may be concerned about having her own personal space.

Neglect and Abuse in the Context of Alcoholism

Six out of nine articles (66.7%) analyzed neglect and abuse in the context of alcoholism and identified a correlation between addiction and the neglect and abuse of children and adolescents (Lown et al., 2010; Nodar, 2012; Rangarajan, 2008; Silveri, 2012; Doumas et al., 2015; Johnson & Stone, 2009). Alcoholism is identified as a key contributor to domestic violence (Vaillant, 2006). According to Green (2015), children of alcohol abusers often experience neglect and abuse. Child abuse is ranked as one the most prevalent consequences of alcoholism; in fact, research shows that addiction is a factor in nine out of ten cases involving child abuse, and two of every five alcohol addicts are abusive (Green,

2015). According to Johnson and Stone (2009), physical abuse of children is very common in alcoholic households, as many alcoholics are violent and often act without reason or provocation. Unfortunately, children and adolescents often find themselves the principal victims of abuse (Nodar, 2012). Physical abuse of children leaves them with physical injuries, the most common of which are cuts, burns, lacerations, bruises, welts, and fractures (Nodar, 2012).

Too often people who abuse alcohol also commit sexual abuse (Lown et al., 2010). Children and adolescents are more vulnerable to sexual abuse than adults are, because they are innocent and unsuspecting. Also, children make easy targets, as they have no voice to speak for themselves and are easily threatened (Vaillant, 2006). Doumas et al. (2015) reported that many child sexual abuse cases are in fact related to alcoholism. Under the influence of alcohol, parents or family relatives sometimes become the main perpetrators against their children. According to Lown et al. (2010), many children who are sexually abused suffer at the hands of people they know who are under the influence of alcohol. Common sex offenses committed by alcohol abusers against children include sodomy, fondling, and incest (Green, 2015).

Alcoholic effect that elicits altercations between parents manifests as a form of emotional abuse to the children and adolescents (Silveri, 2012). Research indicates a correlation between alcoholism and the mental health issues of children (Włodarczyk et al., 2017). Children and adolescents with alcoholic parents often suffer from mental issues including loneliness, fear, suspicion, and anxiety (Elements Behavioral Health, 2017). According to Teicher et al. (2012), more severely abused children and adolescents develop a reduced volume in some parts of the hippocampus and will suffer from some mental incapacity consequently.

In addition to the outcomes addressed above, children and adolescents of alcoholic parents also face neglect (Doumas et al., 2015). The result from Rangarajan (2008) indicated that parental alcoholism affects parental attachment to their kids negatively. Alcoholism leads to unstable families in which children are deprived of basic needs if their parents' priorities are on other things (Navarra, 2007). According to Green (2015), when parents spend their money on alcohol first, children are often left with less. Furthermore, neglect has far-reaching effects on a child's growth and development. Alcohol-dependent parents do not present strong parenting skills, and, therefore, are not able to effectively teach and guide their children to become responsible adults (Carstairs, 2011).

Parental Capacity in the Context of Alcoholism

Four out of nine articles (44.4%) discussed parental capacity in the context of alcoholism (Navarra, 2007; Galvani, 2006; Carstairs, 2011; Dumas et al., 2015). Society's progress relies heavily on the health and welfare of the family unit; thus, parents are at the core of a community's well-being (Carstairs, 2011). However, a household with one or more caretakers demonstrating alcohol dependency also exhibits diminished parenting capacity. As reported by Navarra (2007), drinking parents have less time for the family. In fact, periods of time may pass in which they have no contact with the children. Research also indicates when one parent's drinking adversely affects his or her spouse, insufficient focus remains to adequately nurture their children (Galvani, 2006). Most people married to alcohol abusers live with known as well as unknown fears (Navarra, 2007). They often do not know what will happen from moment to moment. Consequently, they are anxious, distracted, and fail to build trust with their children, which can impede a child's vital developmental skills. As a result, a gap often exists between even the nondrinking parent and the children (Carstairs, 2011). Also, the parent who is not abusing alcohol might take his or her frustrations out on young family members (Dumas et al., 2015), making them the direct victims of an alcoholic environment. If conditions persist, the children will also learn that violence is the norm; in time, they might also become aggressive (Nodar, 2012).

Psychological Effects of Alcoholism on Children and Adolescents

Three out of nine articles (33.3%) focused on the psychological effects of alcoholism on children and adolescents (Nodar, 2012; Johnson & Stone, 2009; Silveri, 2012). A child's behavior relates to what he or she copies or encounters from the environment (Nodar, 2012) and is directly linked to one's psychology (Silveri, 2012). Children and adolescents of alcoholics face a high probability of also becoming regular alcohol users (Nodar, 2012). Studies indicate that brain development continues into an individual's early twenties; thus, the continual repercussions of an alcoholic environment can lead to severe consequences (Johnson & Stone, 2009). Children born to alcoholic parents are vulnerable to anxiety and depression, consequences of continual conflicts and violence in their home (Nodar, 2012). Children and adolescents from alcoholic family also tend to pull away from others, because of a learned fear of rejection taught by their parents' behavior toward them (Nodar, 2012).

Discussion

Children and adolescents exposed to alcoholism are deprived of essential services and necessities in their lives. This kind of denial affects their development and impacts their social behaviors (Silveri, 2012). One critical need that is not met is having someone to trust (Carstairs, 2011). If trust in others is absent in the early stages of a child's development, problems will likely surface in that child's future (Elements Behavioral Health, 2017). Children and adolescents need someone in whom they can confide and with whom they can share their daily activities, thoughts, and questions (Carstairs, 2011). They feel secure knowing that trusted family members hear their voices and are aware of their endeavors, but alcoholism is associated with loss of family time, denial, and unreliability; and in such an environment, trust cannot be built (Navarra, 2007). Children raised in homes where alcohol is abused typically have difficulty trusting people (Nodar, 2012). Children and adolescents exposed to alcohol abuse also exhibit high levels of stress and depression. The stress and depression dramatically impact their social behavior, and because they are often alone, they tend to be hostile if approached (Silveri, 2012). Stress caused by the influence of alcohol in the family can also cause low self-esteem in children who consequently find it difficult to interact with peers (Nodar, 2012). Financial hardship can also play a role in families of alcoholics (Vaillant, 2006), resulting in situations that predominantly affect the household's innocents. Families struggling with alcohol abuse usually have trouble balancing routine expenses on top of alcohol purchases (Navarra, 2007). At times, therefore, the family sacrifices school fees, rent, clothing, food, or other necessities. Forgoing some of these basics as a child can dramatically affect his or her developmental stages, which impacts their future lives (Nodar, 2012).

These basic needs are critical and should be addressed to minimize future harm to children and adolescents exposed to alcohol, including their physical development, self-esteem, psychological behaviors, mood disorders, academic performance, and substance abuse (Nodar, 2012). Alcohol addicts need step-by-step guidance to control their levels of consumption and education about the problems that society must then manage (Lemon, 2008). Children must also learn the pros and cons of alcohol use and the harm it can cause them and their loved ones (Rangarajan, 2008). Before implementing these practices, adults must be proactive and lead by example. Responsible adults must control how they consume alcohol to teach children the same most effectively (Nodar, 2012).

Conclusions

Alcoholism is a major social problem in most countries (Green, 2015). Not only does it affect the users of alcohol, but drinking also affects the whole of society (Vaillant, 2006). Children and adolescents are at the center of this menace, as they suffer myriad negative consequences when exposed to alcohol abuse. This literature review highlighted ways in which alcoholism affects the youngest members of society and offered suggestions to help avert its future impact. As parenting skills play a significant role in the healthy development of a child (Carstairs, 2011), efforts should be made to enhance parenting awareness and capacity. Children and adolescents represent the most vulnerable victims of alcoholism and are most drastically affected by its consequences (Marshall, 2014); therefore, protecting our youngest generation is urgent and is everyone's responsibility.

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Demonstration as Instructional Tool, Effect on Learning

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Abstract

Demonstrations are widely used and respected instructional tools in chemistry and other sciences because they provide real examples of everyday life and help students visualize and apply concepts. This paper reports on the results of a study that evaluated the effectiveness of laboratory demonstrations versus self-directed student experiments in an introductory chemistry course. Final examination scores across 12 semesters for each method of teaching were compared statistically. Scores on the demonstration portion of the examination were significantly higher on average than the scores on the experiment portion of the examination. This suggests that demonstration could be a more effective method of helping students retain information than self-directed experiments. Students from 6 semesters were given surveys that asked them to rate their comprehension and retention rates from the 2 teaching methods. The survey indicated that students in general retain information better from demonstration. The general consensus among students was that demonstration is easier to follow and understand.

Introduction

Demonstration has become a nationally recognized instructional tool in classrooms ranging from K-12 to college classes. Demonstration provides a live example of a concept or a theory that is discussed in class. It also connects between the concept or theory and daily life practices. Moreover, it provides a method of teaching that fits many students' learning styles, particularly those who fall under the lower end of the learning curve, and ultimately facilitates learning the subject. Generally, science courses have a laboratory component that can be used to back up the lecture and reinforce the learning process. Chemistry is an example of what many students call a "complex subject." Demonstration can be particularly useful in helping the students develop learning strategies that fit their learning styles and help them succeed in the course (1,2).

Lower-division chemistry courses are typically problematic for students to master. For example, in introductory chemistry courses, where the majority of the students have the intention, and some have the desire and potential, to earn a science degree, they quite often switch to non-scientific majors because of the complexity of the subject. In most cases, the teaching style in introductory science courses plays a significant role in the student's decision toward a major. Demonstration can be utilized as an effective tool to illustrate and strengthen the ties between chemistry and other sciences and make the subject more accessible to students.

An important consequence of using demonstrations in lower-division chemistry classes is that more students may become interested in pursuing a degree in chemistry. Many chemistry majors choose to pursue that degree because they discovered an interest in chemistry in one of their lower-level courses. It has been speculated that freshman entering college with the interest and ability to pursue science degrees are driven away by introductory-level science classes (3). Some reasons that students are driven off by these courses are professors' failure to motivate by teaching real-life application, students' failure to be involved in the classroom, and professors' failure to teach concepts instead of algorithmic problems (3). Demonstrations can be very useful in alleviating these problems, especially when a POE (Predict, Observe, Explain) model is used to carry out the demonstration (4). Students become actively involved in learning when they are asked to predict the outcome of a demonstration and the concept underlying the experiment can be seen visually. Also, by doing demonstrations that apply to everyday life, students can become more motivated to learn chemistry.

In a typical science laboratory session, the first few minutes are chaotic. Flipping through the pages of the book, reading about the experiment, and talking to each other are typical activities of students at the

beginning of the session as noticed by instructors. These undesired behaviors could be attributed to chemistry laboratory anxiety that directly affects self-efficacy in the laboratory and students' attitude towards chemistry (5). Toward the middle of the experiment, students usually start rushing to get things done and wrap up the experiment. As a result, the learning goals may be jeopardized and lasting learning unlikely to occur. With a demonstration, much of this chaos can be easily eliminated because the instructor performs the experiment (as a demonstration) to the entire class, while guiding the discussion among students to facilitate predicting outcomes before each step of the demonstration and recording the observations. The lower stress of the demonstration and the ability to predict outcomes may help students to retain more information from the activity.

It has been shown elsewhere that using demonstrations in a chemistry laboratory followed by the students turning in reports on the demonstrations can be just as effective as when students perform self-directed experiments (6,7,8). Another study revealed that demonstration derives significant learning improvements among first-year college students (9). These improvements occurred in both strong and weak students.

In this paper, we report the effect of demonstration on the learning process in an introductory chemistry laboratory. Over several years, it was noted that a high percentage of students who sign up for introductory chemistry have little or no background in chemistry. Therefore, they show poor performance in the laboratory and are usually less receptive of the instruction and discussion throughout the laboratory session. To overcome these problems and to promote learning at the introductory level of chemistry at our institution, the curriculum of the introductory chemistry laboratory was developed to include a demonstration component. We followed up on the effect this had on learning outcomes by using different assessment tools that include a standardized test produced by instructors, a questionnaire, and interviews with students and teaching assistants. The results and the findings are presented in this study.

Procedure

A laboratory manual specifically for introductory chemistry was developed to contain 6 self-directed experiments and 6 demonstrations throughout the semester. Each experiment corresponded to a demonstration that covers the same concept as relates to lecture. The experiments and demonstrations are designed carefully to be at a comparable level of difficulty and require the same amount of time to complete. In the experimental portion, the students carried out the experiment with lab partners under the supervision of the instructor. In contrast, demonstrations were

presented by the instructor to the entire class while the students observed, predicted, and recorded data. After the demonstration was completed, the students were given enough time to analyze the data and answer the questions provided in the text. After that, students were asked to generate a lab report about the demonstration similar to what they typically do after the experiment.

In the first week of the semester, the students were divided into two groups of about equal counts, group "A" (students with last name beginning with A–L) and group "B" (students with last name beginning with M–Z), and were directed towards one activity per week. Usually group "A" students were directed towards demonstration #1 and group "B" students towards experiment #1. In the next week, the two groups were switched and so on until both groups completed all 6 experiments and 6 demonstrations by the end of the semester.

Retention and comprehension of information from laboratory activities were assessed using various assessment tools that include a final examination, a questionnaire, and interviews with students and teaching assistants. The final examination given at the end of each semester consisted of 2 sets of questions. One set covers the experiments while the other set pertain to the demonstrations. Multiple-choice format was used on the test to avoid having variation in the grading process. The performance of students on the 2 sets of questions was compared across 12 semesters.

Near the end of the semester, a questionnaire was developed by instructors and laboratory assistants (see Appendix A) as an assessment tool to judge the effectiveness of demonstration/experiment on learning. The questions reflect quantitatively the retention rate of information from the self-directed experiment and demonstration and give insight into the learning styles of the students in introductory chemistry.

Six groups of students were surveyed during 6 consecutive semesters, including 2 summers and 4 regular semesters of fall and spring. All but two of the questions of the questionnaire had students report their response in a percentage, which was then averaged for each semester. The other two questions were multiple choice, and the number of each response (a, b, or c) per semester was counted and the percentage of each response was calculated.

The average number of students in each section of experiment/demonstration was approximately 20 students. The same instructors were assigned to teach both the experiment and the demonstration during the entire period of study. All experiments/demonstrations were scheduled during mid-afternoon at the rate of one activity per week per group.

Results and Discussion

A statistical analysis of the scores of the 2 instructional methods (demonstration and experiment) was performed using SPSS software. There were 1054 observations (N) for each method. Descriptive analysis of the two samples showed an average of 76.15% for experiment and 82.22% for demonstration, a difference of about 6% on average. The median scores show similar results at 83.33 and 77.2, respectively. This suggests a substantial and meaningful difference between the average scores for the samples considered. Moreover, the standard deviations (and standard errors of the mean) were 11.7 and 11.36 (and 0.36 and 0.35) respectively, which suggests a similar variation in the demonstration and experiment scores. These results are summarized in Table 1.

Teaching method	Mean	SD	SEM	Median
Demonstration (%)	82.22	11.7	0.36	83.33
Experiment (%)	76.15	11.36	0.35	77.2

Figure 1 shows a graphical illustration of the percentage scores of the two instructional methods. In this graph, demonstration is referred to as “D” and experiment as “E” on the x-axis. The y-axis represents the score percent of each category. The box plots illustrate the differences between demonstration and experiment score outcomes. Clearly, the demonstration scores distribution is higher than that of the experiment scores. We also looked into the differences semester by semester. A graphical display of those comparisons is shown in Appendix B.

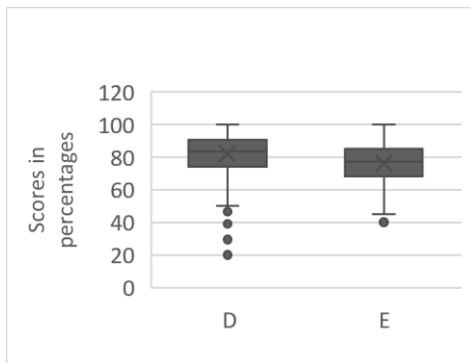


Figure 1. Graphical representation showing distribution of demonstration and experiment scores. The presence of outliers is also reported in the graph as solid circles. X indicates the numerical average.

The discovery of actual practical differences between the two teaching methods naturally resulted in studying the statistical significance of these differences between the two instructional methods' scores. First, a normality test was performed; we found that the data sets deviate from normal distribution. Because of the abnormal nature of the data sets, a nonparametric test in which the median difference between the two sets of scores was considered. A rank test showed a statistically significant difference between demonstration and experiment scores, with a p-value less than 0.01.

Finally, we estimated a confidence interval for average difference between demonstration and experiment scores. The difference was at least 5 points in favor of the demonstration teaching method.

To further the analysis of the data beyond statistical comparison of central score values and the variations of the scores for each group, the scores were cross-tabulated using two categories: teaching method and scores split on pass–fail basis. The question was one of independence. Are passing–failing scores independent of the teaching style? The results are presented in Table 2. The rows in the table represent the teaching method and the columns represent the observed count in each score category (at or above 70%, and 69% or below), the expected count under the hypothesis that the teaching method and the scores are independent. There were 903 (88.3%) scores in the demonstration classes that are at passing level and 120 (11.7%) failing scores. The counts for experiment classes were 791 (76.6%) and 241 (23.4%) respectively. Under the (null) hypothesis of independence, we would expect only 846 and 850 passing scores and 180 and 181 failing scores respectively.

Table 2. A cross-tabulation of teaching methods and scores				
Teaching method	Statistic	Fail	Pass	Total
Demonstration	Count	120	903	1023
	Expected Count	179.7	843.3	1023
	% within Exp-Dem	11.7%	88.3%	100%
Experiment	Count	241	791	1032
	Expected Count	181.3	850.7	1032
	% within Exp-Dem	23.4%	76.6%	100%

A Chi-square test for independence between the teaching styles considered in this research and students doing well in these classes shows a strong statistical significance with a p-value < 0.01 . The evidence from this test suggests an association between teaching methods and high (passing) student scores. Demonstrations significantly increased the number of students scoring high in their tests by a substantial margin.

The results of the questionnaire were compiled into two comprehensive data tables (Tables 3 and 4) based on the format of the question. Table 3 presents the percentage average of students' responses to each of the questions 1, 2, 4, 5, 7, and 8 per semester. Table 4 presents the percentage average of students' responses to multiple-choice questions 3 and 6 per semester. The number of each response (a, b, or c) was counted and a percentage for the semester was calculated.

Table 3. Percentage averages of questionnaire responses and number of students per semester						
Question	Semester					
	Spring I	Summer I	Fall I	Spring II	Summer II	Fall II
1	70	80	71	73	83	77
2	58	72	53	69	85	68
4	54	77	57	61	75	63
5	49	71	45	55	74	57
7	67	83	75	72	88	78
8	64	75	64	69	83	72
Total # Students	72	33	56	58	23	88

When results from questions 1, 2, 4, 5, 7, and 8 were analyzed, a noticeable trend developed. These particular questions asked the students to rate their comprehension and retention of the experiments and demonstrations as percentages. In comparing question 1 with question 2, students rated their comprehension of new information from demonstrations at 8.0% higher, on average, than from experiments. Similarly, students rated their retention from demonstrations 6.0% higher than from experiments (questions 4 and 5). Questions 7 and 8 once again rated comprehension from demonstrations by an average margin of 6.0% over experiments. Note that in only one case (Summer II) did experiments rate higher than demonstrations.

In comparing the multiple-choice questions of the survey, questions 3 and 6, very few trends could be identified (Table 4). One noticeable trend according to question 3 seemed to be that students prefer a mix of experiments and demonstrations to doing one or the other exclusively. When we limited the choice between demonstrations and experiments, students seem to have mixed opinions over different semesters. For example, in year 1, the survey showed a preference of experiments over demonstrations, while year 2 showed just the opposite. This inconsistency seems to be due to other factors that play a role in the students' decisions. Results from question 6 were also mixed and did not clearly follow one trend.

Table 4. Percentage averages of multiple-choice questionnaire responses and the number of students per semester

Question	Semester					
	Spring I	Summer I	Fall I	Spring II	Summer II	Fall II
3a	23	9	12	43	17	28
3b	39	27	43	17	13	7
3c	38	67	45	40	70	41
6a	40	21	43	30	35	25
6b	36	30	28	40	10	22
6c	24	49	29	30	55	26
Total # Students	72	33	56	58	23	88

Therefore, the only conclusion that could be drawn from the students' responses to this question was that there was a mix of students in the classes that were primarily motivated by learning, completing the course, or just finishing the lab. On average, however, the demonstration score was slightly higher than the experiment score. This would suggest that demonstrations are a more effective method of helping students retain information than self-directed experiments.

In conclusion, the analyses of both test scores and questionnaire results provide clear evidence that students comprehended and retained information from demonstrations better than they did from experiments, and there is a statistically significant difference between the two teaching methods. Similar statistical findings are reported among middle school students in a chemistry class (10).

Results of interviews with students and teaching assistants followed the same trend. Most of the interviewed students stated that they favored observing demonstrations over conducting experiments by themselves. However, these results should not mean that self-directed experiments should be abandoned completely in favor of demonstration, because the importance of students gaining hands-on laboratory experience is a crucial aspect of chemistry, and it is not possible to weigh its significance in this study.

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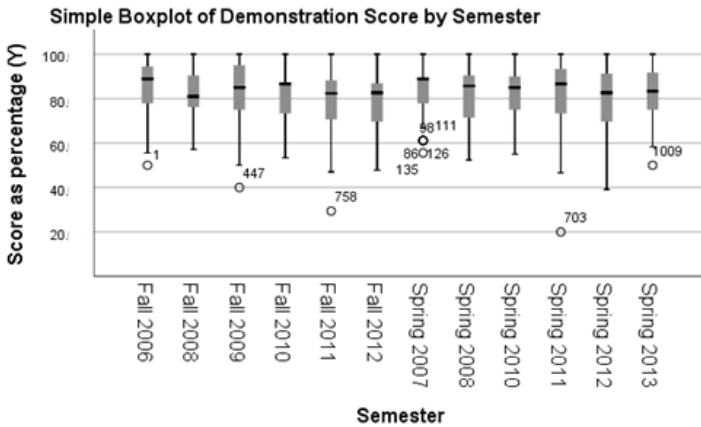
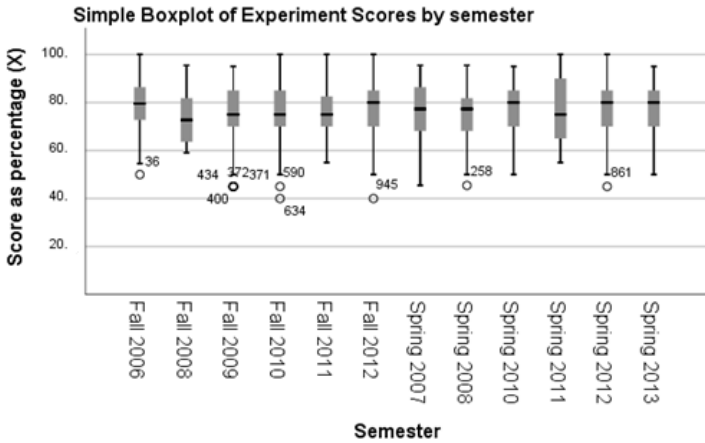
Appendix A

The following is a transcribed copy of the questionnaire given to students:

1. What percent of new information do you feel that you comprehend from the demonstration? _____
2. In contrast, what percentage do you think that you comprehend from the lab experiment? _____
3. Out of the two choices, lab and demo, which is your learning style?
 - Demo
 - Lab
 - 50/50
4. What percentage of information do you feel that you retain from the prior week's demonstration? _____
5. What percentage of information do you feel that you retain from the prior week's experiment? _____
6. If you were to choose a word that reflected your true thoughts of the lab experiments, what word best fits?

- Getting the correct answers to benefit your grade
 - Getting the lab completed
 - Comprehension
7. What percentage of information do you feel that you comprehend when you observe the professor doing the experiment? _____
 8. What percentage of information do you feel that you comprehend when you carry out the experiment yourself? _____

Appendix B



Gearing Up for a Launch of a VASIMR Rocket at Utah Valley University

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Abstract

A VASIMR, or Variable Specific Impulse Rocket, is a magnetoplasma rocket that has been touted as the best plausible technology for executing large-scale missions to Mars and other planetary missions. State-of-the-art VASIMR technology uses a helicon antenna to excite a plasma, which passes longitudinally along a confining magnetic field where it is further energized by ion-cyclotron resonant frequency (ICRH) heating. A final magnet provides the field structure to act as a nozzle in which nearly all the plasma kinetic energy is converted into longitudinal thrust. We are constructing a small version of the device at Utah Valley University to serve as a platform for studying plasma physics. We present here the baseline physics of the device and the plasma parameters that may be produced and explored as dictated by the constraints of the device size, magnetic field strength, vacuum equipment, and radio frequency sources, etc. The project is in its early stages, and we anticipate that it will evolve in time to provide substantial opportunities for

undergraduate research. Our system currently consists of a 3-inch-diameter vacuum vessel, one meter in length, with two wound coils and magnetron radio frequency source for plasma excitation, and an argon source. Studies are underway to fabricate an ICRF and helicon antenna. Undergraduate participation in the project includes instrumentation and magnet design, fabrication and characterization, software interfacing, and plasma modelling.

Introduction

The Variable Specific Impulse Magnetoplasma Rocket (VA-SIMR)[1] is the invention of physicist and former astronaut Franklin Chang Diaz. The original idea stemmed from Chang Diaz's experiences in fusion research at MIT. "Magnetic mirrors" were widely explored at the time but never proved up in advancements toward fusion for the simple reason that they were too leaky [1,2]! In the absence of collisions, rapidly changing fields, and turbulence, the magnetic moment of an ion in a magnetic field is conserved, or constant in time. For an ion of charge q , and mass m , moving parallel to a magnetic field \vec{B} , with speed v_{\parallel} and gyrating around it with speed v_{\perp} , the magnetic moment is $|\vec{\mu}| = \frac{mv_{\perp}^2}{2B}$. It is readily apparent that conservation of the ion's kinetic energy also requires that v_{\parallel} decreases as the magnetic field increases, such as it would in the throat of a strong solenoid. Given a strong enough field and field gradients, the ion could reverse direction, or 'mirror,' when the axial field became too strong. In principle, a set of axially aligned magnets would constitute a mirror for confining the plasma for arbitrarily long times. In fact, plasma instabilities and collisional behavior ensure that there is enough scattering of plasma into a loss cone that long confinement times are not possible. Chang-Diaz realized, however, that the magnetic mirror could serve as the basis for a rocket engine, exploiting the lost plasma as fuel. The basic idea was to use a magnetic mirror configuration to act as a magnetic nozzle. Radio frequency (RF) energy from a helicon antenna would be used to ionize a plasma in the 'magnetic bottle' region, in which the plasma would be confined just long enough to be further energized by RF energy from an ion-cyclotron resonance heating (ICRH) antenna[3], rapidly enough to increase the ion's magnetic moment. The plasma would then expand adiabatically in the nozzle, providing thrust.

In slightly more detail, the central physics of the rocket follows from the behavior of individual ions in a magnetic field. Magnetized ions gyrate with a characterized Larmor or gyro frequency $\omega = \frac{qB}{m}$. As stated

above, in the absence of collisions or accelerating electric fields, the magnetic moment of an ion is constant in time. Likewise, conservation of energy requires that the kinetic energy $E = \frac{1}{2}mv_{\parallel}^2 + \frac{1}{2}mv_{\perp}^2 = \frac{1}{2}mv_{\parallel}^2 + \mu B$ is also constant. Thus, the component of velocity parallel to the field can be written $v_{\parallel} = \left(\frac{2}{m}(E - \mu B)\right)^{\frac{1}{2}}$. In a region of increasing B , v_{\parallel} decreases, while conversely in the magnetic nozzle region, where the field is decreasing, it increases, and this constitutes the production of thrust. The actual generation of thrust is contingent upon “plasma detachment”, that is, the magnetized plasma must detach from the dipole field of the solenoids at some point in the wake of the rocket. The Ad Astra VX-200 experiment reports the production of thrust along with evidence of detachment, but the explanation of detachment lies beyond the scope of this paper [4,5].

In a VASIMR, the ICRH antenna produces a circularly polarized E-field perpendicular to the B-field that directly increases v_{\perp} and hence an increased μ in the region of the antenna, which leads to the increase in v_{\parallel} in the weakening field of the magnetic nozzle.

Utah Valley University (UVU) does not offer graduate degrees in physics. Plasma physics is not normally taught as an undergraduate topic; however, it is rich with physical phenomena applicable to a wide variety of research disciplines, from material science to astrophysics. Initiating a study of the VASIMR in an undergraduate environment is taken as an opportunity to introduce students to a wealth of techniques and physical concepts that may enhance and solidify their preparation for postgraduate careers. These include the explorations of plasma discharges, RF electronics and power systems, spectroscopy, vacuum systems, and a host of other allied experimental and data analysis techniques.

The UVU VASIMR laboratory aims to engage students in the long-term development of different facets and experiments in the rocket. At the outset of the program, the goals were to develop the vacuum and argon feed systems and RF plasma excitation capabilities and to explore some of the parameters of a magnetized plasma.

The UVU VASIMR laboratory currently consists of a 3-inch-diameter borosilicate glass tube, with a roughing and turbo pump, along with rudimentary magnets and an RF heating system salvaged and constructed from a kitchen microwave oven with a nominal 0.7-kw power output at $f_o = 2.45$ GHz, and a nominal wavelength of $\lambda_o = 12.2$ cm.

Some iteration was required to effectively isolate the magnetron system with a large Faraday cage. Early incarnations of the device using

a ¼-inch wire mesh proved too leaky even for the nominal 12-cm wavelength of the RF source. Aluminum mosquito netting was eventually selected as the screening material. The magnetron transmits the transverse electric TE_{01} mode at this wavelength and is oriented in the chamber so that the E-field is at right angles to the length of the tube. A discharge is also produced with the field parallel to the length of the device. The magnetron sits immediately beneath the tube with the beam propagating upwards. A simple rubber hot-water bottle placed on the top of the plasma tube is used as a beam stop. A plasma discharge is nevertheless excited throughout the volume of the tube. Figure 1 shows the apparatus under discharge.

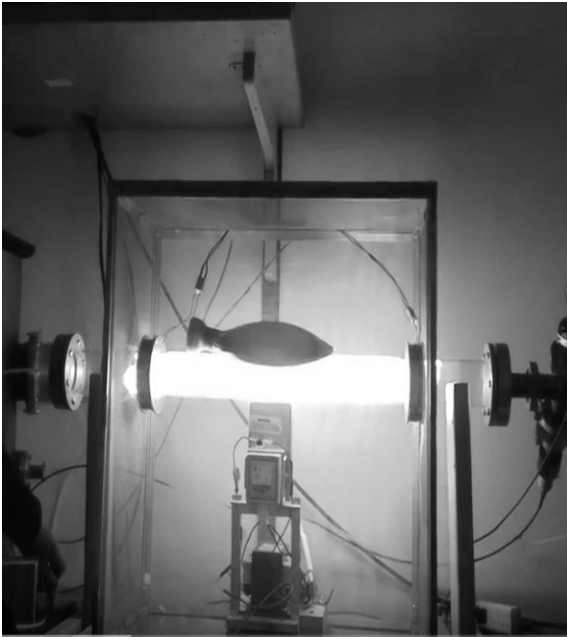


Figure 1. A non-magnetized argon plasma is produced from RF emissions of a magnetron (center). The water bottle on top serves as a beam stop. In this case, the two solenoidal magnets are at either end of the tube and not energized. Argon enters from the left, and the vacuum pump is on the right. A fine aluminum screen mesh surrounds the discharge tube to act as a Faraday cage.

Our system is modular in design and is easily upgradable for future projects. The current iteration has a 1-meter-long, 3-in-diameter, borosilicate tube; an argon gas inlet; a roughing pump and turbo molecular pump; Duniway Stockroom Corp (Fremont, CA) pressure gauges; and a

70×70×40-cm Faraday cage surrounding the discharge area. Inside the cage are two axial magnetic coils, our magnetron circuit, and a luminosity probe. The magnetic coils have a maximum magnetic field of about .05 Tesla and can be placed anywhere along the tube. These are individually powered with two BK Precision (Yorba Linda, CA) DC power supplies. The magnetron and other circuit components were stripped from a generic 700W LG microwave. We have been using the luminosity probe, paired with pressure gauges, to perform initial studies of plasma production. Empirical iteration on placement of the magnetron was used to optimize the plasma discharge.

Discussion: System Plasma Parameters

Ad Astra reports that the gas/plasma pressure in the central thrust-producing discharge is a few torr [2], and thus we examine discharges in argon of between 0.1 and 8 torr. Outside this range, we are unable to sustain a discharge.

At the high-pressure limit, the discharge forms an interesting and complex standing wave pattern, possibly reminiscent of Faraday dark spaces seen in Crookes gas tube discharges. We have no immediate understanding of the structure. At pressures nearing 0.1 torr, the discharge simply stops, presumably because the electron and neutral densities are too low to sustain a collision cascade.

Although not in a high-vacuum, collisionless regime, it is instructive to examine individual ion characteristics to infer possible operational parameters of the plasma. The size of our tube limits the range of values for ion gyro radii. Assuming a plasma of temperature kT , and a thermal velocity of order $v_{th} = \sqrt{\frac{kT}{m}}$, with a gyro frequency previously defined, we obtain an expression for the gyro radius of $R = \frac{v_{th}}{\omega} = \frac{\sqrt{mkT}}{qB}$. Taking the device radius as the limit for an argon ion gyro radii suggests a limiting plasma temperature of $T \approx \frac{(qBR)^2}{mk} \approx 60,000$ K. In any case, the thin plasma colliding with the cold wall would invariably cool the plasma well below this limit. The residence time of an ion between magnets spaced a distance L apart is roughly, $\tau = \frac{L}{v_{th}} \approx L \sqrt{\frac{m}{kT}}$. For the ICRH to be effective, τ must be commensurate with the ICRH RF period, suggesting a frequency for energizing the plasma of $\omega_{ICRH} = \frac{2\pi}{\tau} = \frac{2\pi}{L} \sqrt{\frac{kT}{m}}$, or substituting for the limit on the temperature, $\omega_{ICRH} \approx \frac{2\pi\omega R}{L}$. The aspect ratio of the device can be varied by placement of the solenoids, but

overall the factor $\frac{2\pi R}{L}$ is of order one, giving an ICRH frequency for our system of $f_{IRCH} \approx 100$ kHz.

The ICRH E-field maybe approximated by a circularly polarized poloidal field that is constant over the volume containing the magnet bottle. The energy gained over one cycle of the oscillation by one ion will be about $\Delta\left(\frac{mv^2}{2}\right) \approx qE2\pi r$. With the gyroradius being the limit on r , the maximum amplitude of the accelerating field can be inferred to be $E_{max} \approx \frac{RqB^2}{2\pi m}$ or about 1000 V/m for the device. This allows for a simple estimate of the maximum power required of the ICRH antenna of about 300 watts. The design and construction of the antenna remains as a project for the future.

Initial investigations

Initial student efforts have been centered on getting the vacuum system, Faraday cage, and magnetron RF source to function properly in reproducibly exciting discharges in an argon plasma. Such discharges have long been studied [6,7], but not in the context of producing an exhaust plume. As a brief initial study, the plasma luminosity versus gas pressure was characterized by cycling the gas pressure up and down through the range of 0.1 to 5 torr and measuring the resulting luminosity. At lower pressures, the discharge is hard to sustain, while at higher pressures the discharge breaks up into the “Medusa Mode” shown in Figure 2.

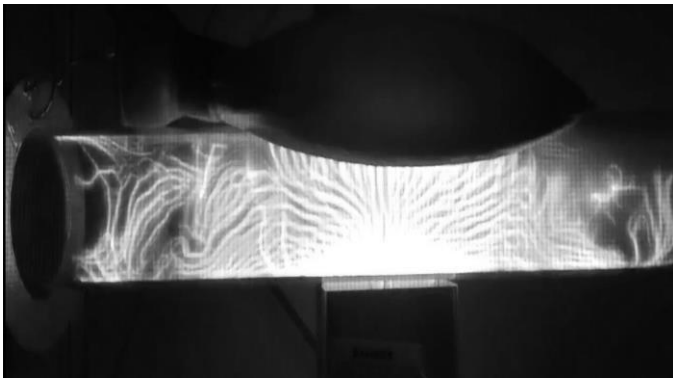


Figure 2. At pressures between 4 and 8 torr, the discharge forms an interesting standing wave pattern, which has been whimsically dubbed “the Medusa Mode.” The spacing between the luminous filaments is approximately 1 cm.

Figure 3 shows typical results for the experiment. Between 0.1 and 0.5 torr, the luminosity varies with the argon pressure p as $p^{-0.3}$. At higher pressures, the luminosity again increases, in a “bathtub” curve reminiscent of, but not necessarily simply related to, the Paschen Law curve [7] for the discharge excitation voltage as a function of pressure. A naive conjecture is that at higher pressures, electron-neutral collision frequency is greatly increased, and fairly low-energy electron impact dominates the spectrum, while at lower pressures, electron energy increases with decreasing pressure, resulting in more ionizations, and hence more recombination and excitation events.

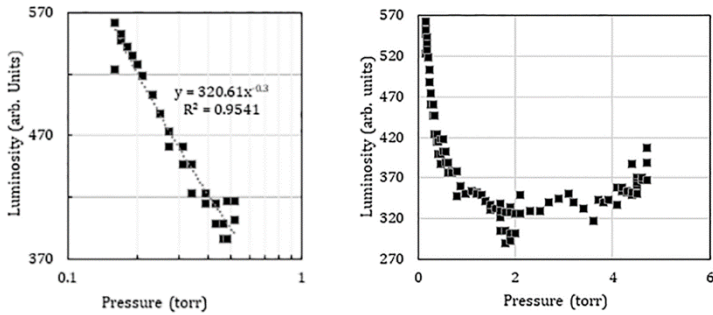


Figure 3. (Left) The argon plasma luminosity was observed to increase with decreasing pressure, varying with $p^{-0.3}$, over a range of 0.15 to 0.6 torr (log scale). (Right) At higher pressures, the luminosity again increases with pressure (linear scale). At sufficiently low pressures, the discharge is not sustained, while at higher pressures, the plasma first becomes massively filamentary as in Fig. 2, before failing.

No effort has yet been made to quantify the gas temperature or plasma density and electron temperature, pending the set-up on appropriate spectroscopic equipment.

To verify that the plasma responds to an axial magnetic field, a Vernier (Beaverton, OR) Hall probe was placed in the vicinity of the two solenoids and the luminosity of the plasma was recorded as a function of the magnetic field at a fixed pressure. The solenoids were spaced 10 cm apart, and the luminosity was measured at the center, between them. The overall pattern behavior is that as the current in the solenoids is increased, the plasma in the center dims, while the luminosity in the throat of the magnets brightens. We interpret this to mean that a genuine pinch effect is manifest in the now magnetized plasma. Figure 4 reveals that

the central luminosity of the plasma decreases as the field strength increases. The pressure in the case shown was held at 0.24 torr, and the B-field at the center of the solenoids was approximately 0.05 T.

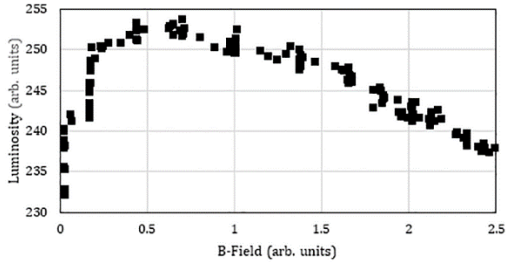


Figure 4. With the two solenoids spaced 10 cm apart, the current is varied and the luminosity observed. The light sensor was positioned halfway between the solenoids, and the pressure was held steady at 0.24 torr. The data verify that the plasma is magnetized and responsive to the field. It was also observed that as the central portion of the plasma dimmed, the region in the throat of the solenoids appeared to brighten, but this is not shown here.

Conclusion

We have undertaken to expand research opportunities in physics at UVU through the mode of designing, constructing, and modeling a VA-SIMR rocket. The project is very much in its initial phase. It is anticipated that, over the course of many semesters, the project will evolve and grow in complexity as new systems are added to it. The choice of using a plasma rocket as a vehicle is motivated by the rich phenomenology associated with plasma physics and the opportunity to investigate a technology that holds the promise of extensive exploration of the solar system in decades to come.

As a tool for introducing the valuable instrumental and experimental concepts into the undergraduate curriculum, the project has born substantial fruit. Students gained experience in assembling and fine tuning a vacuum system, RF system, magnetic system, and various diagnostic components. The students gained skills in machining and in computation, working with Python and other languages. Opportunity was also taken to train student in safety protocols in the use of RF, high voltages, machine tools, and general laboratory procedures.

Plans for the immediate future include the construction of an interferometer to determine plasma temperature and density, improvements

to the magnetron waveguide, and the design and fabrication of a helicon antenna and ICRH antenna. The group also plans to develop a Langmuir probe and improved magnets.

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Magnetic Field Modulation for Magnetron R&D Toward Particle Accelerator RF Source Replacement

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Abstract

Magnetrons are economical radio frequency (RF) sources for driving charged particles through accelerators because of their high efficiency (>80%) and low cost; at present, klystrons are widely used because they are linear amplifiers and have high gain, with relative lower efficiency. Replacing klystrons with magnetrons is therefore of great interest. To be suitable for driving superconducting RF (SRF) cavities, magnetrons must demonstrate injection phase locking and RF amplitude control. An essential feature will be the modulation of magnetron magnetic field to compensate for frequency variation when ramping gain and for cavity microphonics. Previous experiments at Jefferson Lab on a 2.45-GHz magnetron have demonstrated injection phase locking and single trim coil RMS magnetic field amplitude up to 2.92% of the permanent magnetic field. Dual trim coils will be necessary to reach optimum values of 10%. The results presented are from a Summer 2018 REU internship at Jefferson Lab and were preliminary results in preparing for an experiment demonstrating Continuous Electron Beam Accelerator

Facility suitability of a Muons, Inc. (Batavia, IL) 1497-MHz low eddy current magnetron. The internship consisted of 3 major tasks:

1. *Optimization of a trim coil and its bipolar power supply for magnetic field modulation;*
2. *Driving of a warm Niobium cavity with a 2.45-GHz magnetron;*
3. *Design of a 1497-MHz magnetron test stand.*

I. MAGNETRONS AS EFFICIENT RF SOURCES IN HIGH ENERGY PARTICLE PHYSICS

To provide high-energy particles for physical experiment, particle accelerators such as the Continuous Electron Beam Accelerator Facility (CEBAF) use radio frequency (RF) waves to generate an accelerating field in superconducting RF (SRF) cavities that field accelerates electrons. These SRF cavities are made of cryogenically cooled niobium, and the superconducting properties of niobium at these temperatures reduce resistive losses. The cavities optimize the ratio of electric field density (accelerating component) to power loss through the walls of the cavity, as related by the geometry factor $\Gamma = \omega \frac{\iiint_v \epsilon_0 E^2 dV}{\iint_v H_t^2 ds}$,¹ where E is the peak electric field inside the cavity and H_t is the tangential magnetic field. The unique shape of SRF cavities comes from optimizing this geometry factor Γ for minimal RF surface losses at a given stored energy.

Current high-energy accelerators commonly use klystrons for the source of this accelerating voltage because amplifying incoming signal with a klystron does not affect the frequency of the signal. This type of control is essential, as each cavity's signal must be in phase and share a common frequency, otherwise effective acceleration will not occur and the electron bunches will begin to spread.

Magnetrons, on the other hand, are not linear amplifiers like klystrons, but are nonlinear oscillators instead processing saturated gains at steady states. Increasing gain on a magnetron shifts the operating frequency of the device. Magnetrons also have significant noise problems.

The shift of frequency called frequency pushing because of change of gain is one of the most significant problems magnetrons must overcome. If these disadvantages can be overcome, magnetrons can be ideal RF sources for accelerators because of their simple design, low cost, and high efficiency; this efficiency can be up to as much as 30% more than high-efficiency klystrons.² In addition, an effective control design would require a magnetron to compensate for SRF cavity microphonics causing cavity detuning. There is also a possibility for compensation for other effects, such as variations in helium pressure or beam loading wherein

the beam passing through a cavity causes a change in voltage of that cavity.

As it stands, however, magnetrons are already used as RF sources for medical accelerators, and if control technology is developed, magnetrons may see applications in low-cost accelerators for waste water and pollution control for water treatment, power, and chemical plants.

A. Magnetron Operation and Control

A typical cavity magnetron is a vacuum tube consisting of a central cathode (also called a filament) that is heated to energize its freely flowing electrons. This cathode is surrounded by a cylindrical anode (Figure 1), and an electric potential applied across these two elements causes electrons to boil off the surface of the cathode and drift toward the anode, forming hubs or groups of electrons that orbit together. An axially directed magnetic field causes these hubs to spiral into the anode, and as they do they give energy to an RF field in the cavity. The source of this RF field is the resonance of inductor-capacitor circuits formed by the anode block and the gap between vane tips. The resulting space charge forms spokes near the anode vane caps.

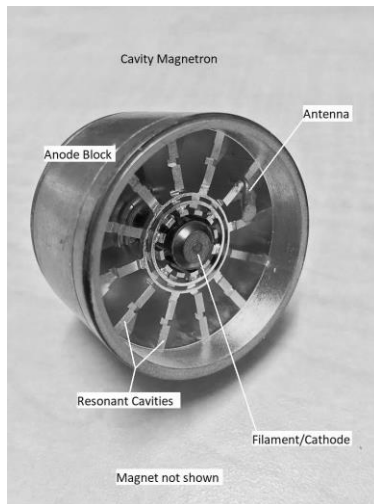


FIG. 1. Photograph of cavity magnetron.

The current scheme proposed by Jefferson Laboratory researchers for accelerator RF source replacement requires controlling magnetron

frequency and noise reduction. These developments require injection lock, magnetic field modulation, and filament control.³

B. Injection Lock for Harmonic Oscillators

Because magnetrons are harmonic oscillators, they can be controlled by an injection signal with intensity and frequency within a certain range. In this case, the output signal from the magnetron can be pulled to a particular desirable phase and locked there for stable operation. From Adler we have the following.⁴

Given an oscillator circuit with resonant ω_0 , cavity loaded quality Q_L , and AC source supplying a voltage E , with incident signal of E_1 and angular frequency ω_1 , the condition for locking (as a voltage ratio) is

$$\frac{E_1}{E} > 2Q_L \left| \frac{\omega_0 - \omega_1}{\omega_0} \right| \quad (1)$$

and the steady-state phase angle α relative to E_1 is

$$\sin \alpha = 2Q_L \frac{E}{E_1} \frac{\omega_0 - \omega_1}{\omega_0}. \quad (2)$$

Now the same method for finding phase also lets us find the instantaneous frequency of operation ω , which is

$$\omega = \omega_0 \left(1 - \frac{1}{2Q_L} \frac{E_1}{E} \sin \alpha \right) \quad (3)$$

For magnetrons, this implies that problems with phase and frequency drift can be in part controlled for by injecting a clean signal into the magnetron to lock its frequency. Even back injection using a signal from the magnetron itself can lock the oscillation of the device and prevent frequency drift if the back-injected signal adheres to the equations above.

Modification of Adler's equation for relativistic magnetrons is given by Chen,^{5,6} and other Jefferson Lab studies found good agreement with his results.^{3,7}

C. Magnetic Field Modulation

To control the output power of a magnetron, the anode voltage must change (this causes a corresponding change in current as more or less electrons boil off the surface of the cathode and flow through the chamber). To compensate for this effect, an externally applied magnetic field

can alter electron bunch orbit, maintaining steady-state phase conditions and reducing the noise.

D. Filament and Noise Control

As mentioned above, electrons inside the cathode get the energy they need to travel to the anode from heating of the cathode. This heating creates noise in the magnetron signal, however, as the heating element gives electrons a chaotic distribution of energies. Once the filament has heated up, it can be kept at a nearly constant temperature by electron back-bombardment. Electrons in the steady state have a more even distribution of energies than when heated externally, and noise is significantly reduced. In addition, Brown⁸ notes that allowing the cathode to be heated by back-bombardment alone not only results in low noise operation but also maximizes the life of the magnetron⁸.

Previous Jefferson Lab experiments have demonstrated the difference between filament-on and filament-off modes of operation and the corresponding noise reduction of up to 30–40 dB, as shown in Figure 2.³

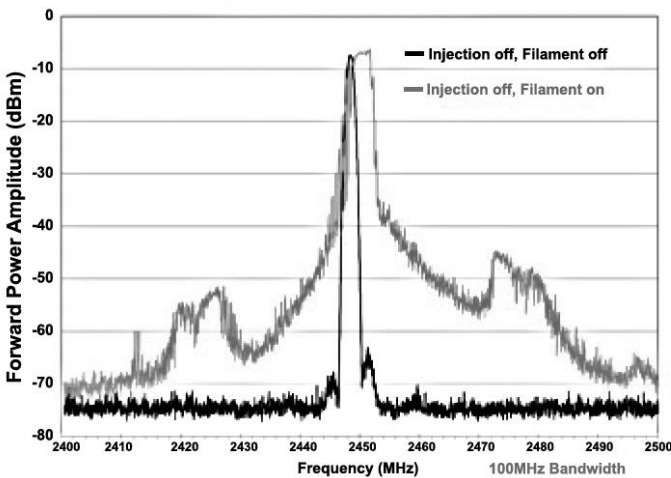


FIG. 2. Comparison of filament-off and filament-on modes of operation with injection off.

II. TRIM MAGNETIC FIELD

The proposed method for modulating the magnetic field requires 2 external trim pancake-style magnets to be mounted outside the magne-

tron body, to compensate for slow beam voltage and cavity microphonics. While the amplitude of this externally applied magnetic field will control for the frequency pushing effect, the magnetic field can be quickly modulated by applying an AC current to the coils to compensate for beam and cavity microphonic effects. Cavity microphonics are dominated by low-frequency vibrations, so maximum magnetic field strength of 10% of the permanent magnetic field at 1 kHz, with a range from 0 to 10 kHz, is ideal. Figure 3 shows the trim coil geometry.

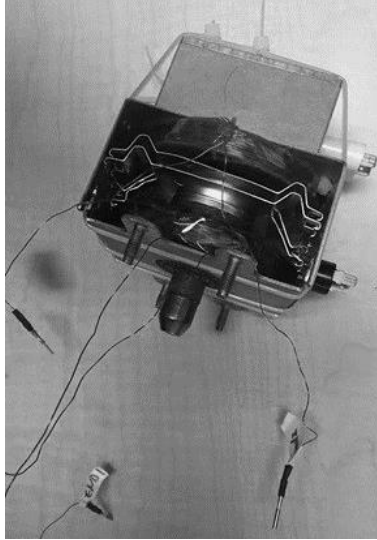


FIG. 3. Photograph showing trim coil geometry.

We believe that the electromagnets act as high inductance multiple-layer solenoids with high proximity effects and that, when they are placed in the magnetron body, mutual interactions with the permanent magnets (made from either ferrite or AlNiCo materials) cause frequency-dependent inductance effects.

A. Trim Coil Data

Mutual interactions with surrounding material causes the trim magnets to exhibit nonlinear behavior *in situ*; however, even in isolation there exists nontrivial frequency-dependent resistance, as seen in Table 1. The coil dimensions were conductor length = 94.1 m, inner radius = 31.9 mm, outer radius = 44.3 mm, and wire diameter = .405 mm.

DC	12.6
100	14.47
120	14.6
1000	17.2
10000	32.8

The resistance effects cannot be described by skin effect alone—the skin depth of copper at target frequencies is at least 0.661 mm, which is greater than the diameter of the wire. Geometry-dependent proximity effects pushing current to a smaller region in the conductor and increasing AC resistance are most likely responsible. Comparison of a litz-wire model to approximate a cross section of the coil bundle is shown in Figure 4.

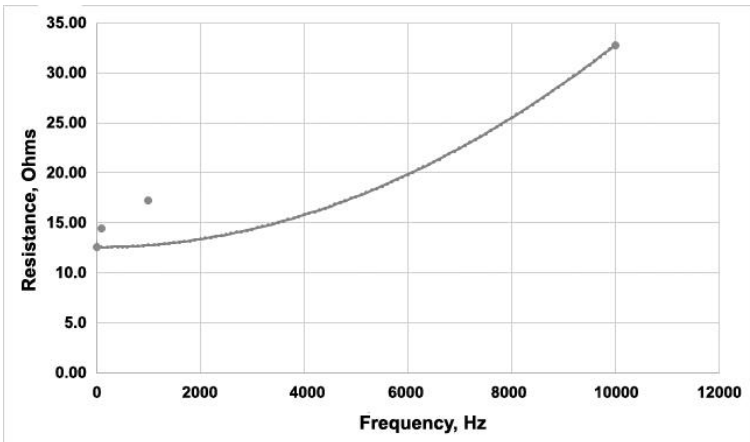


FIG. 4. Graph showing resistance by proximity effect Fr factor.

This plot was found by fitting the first term of a Bessel series expansion of a solution to Maxwell's equations, from Sullivan,⁹

$$R_{eff} = \frac{4\rho l}{\pi d_c^2} \left(1 + \left(\frac{\pi\omega\mu N n(d_c)^3}{\rho b} \right)^2 \frac{k}{768} \right) \quad (4)$$

with d_c being the diameter of the conductor and b the distance across the core. Here k is a function of the maximum to minimum magnetic field ratio $\phi = \frac{B_{max}}{B_{min}}$,

$$k = (1 - \phi^3)/(1 - \phi)^3.$$

By using an LCR meter to measure the trim coil data to fit formula 4, we found $\phi = 1.302$ gave the best fit (Figure 4). Limited measurement options for the LCR meter used allowed for only a small number of measurements to be taken in Figure 4. That the data lies on one side of the curve is likely because of the truncation of the Bessel series expansion from Eq. 4, and inclusion of more terms from the series along with more measurements will likely constitute an improvement to the model.

Because the litz-wire model is an approximation from the first term of a Bessel series (the derivation of which is from a circular cross section of wires in parallel and not from a square torus of wires in series), its applicability is limited. The litz-wire method could approximate the resistance of the wires at DC and 10-kHz levels but gave errors greater than 15% in between. The method can most likely be improved by integration over a rectangular region, although the inductive behavior may cause frequency-dependent k , limiting the scope of this analysis.

In isolation, the coil self inductance is relatively constant at 15 mH with a 1-mH span, but when placed in the magnetron body, the total inductance (mutual and self) of the 2 coils exhibits greatly nonlinear behavior. For finding the self inductance for a single coil in isolation, Terman's method for short multiple-layer solenoids (Equation 5, all constants in inches; using Eq. 52 and Figures 27 and 29 from Terman¹⁰) was used to calculate the constant self inductance of the coil; a value of the right order of magnitude (10.4 mH) was obtained. The appropriate correction factor has not yet been determined. The self inductance is

$$L_{self} = aN^2 J, \quad (5)$$

where a is the width of the bundle in inches, dimensions and J are given by Figures 27 and 29 from Terman.¹⁰

In Table 2 and Figure 5, we see the nonlinear dependence of inductance with frequency, as measured by a digital LCR meter. It is believed that the cause of the concavity of the graph may be hysteresis within the core of the magnetron, which creates out-of-phase flux.

Table 2. Inductance, Coils in Parallel with Magnetron Assembled	
Frequency, Hz	Inductance, mH
100	13.45
120	13.05
1000	8.662
10000	5.709

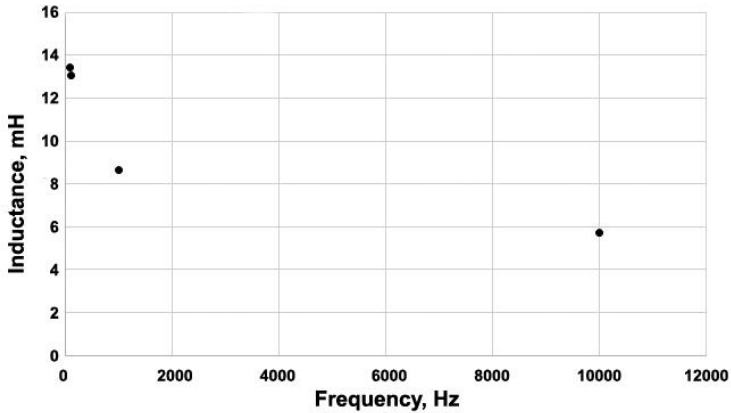


FIG. 5. Inductance effects in magnetron.

B. Trim Coil Magnetic Field

Below we see a plot of the magnetic field generated by the trim coils while assembled in the yoke frame as measured by a Hall probe placed in the magnetron body (Figure 6). Up to 1 kHz, the magnetic field is approximately linear and reaches a maximum of about $\pm 4\%$ of the permanent magnet. Adequate magnetron control requires modulation of up to $\pm 10\%$.

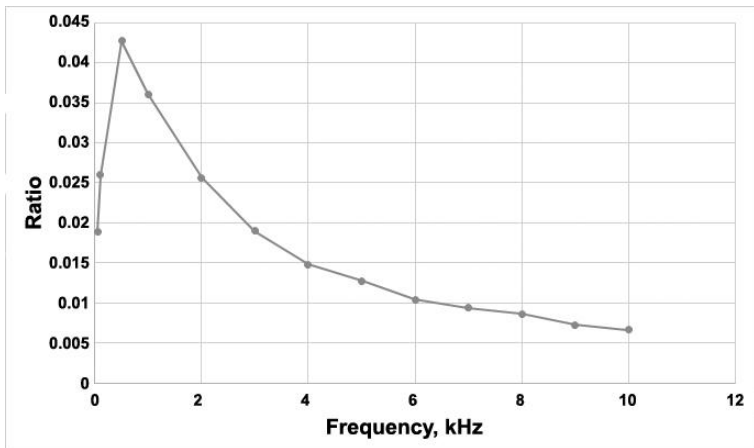


FIG. 6. Graph showing internal magnetic field Bpp/Bdc.

The bipolar amplifier power supply we used to drive the coils was unsuitable for high-inductive loads and had to be refurbished.

III. 2.45-GHZ TEST ON A NIOBIUM CAVITY

One of the main accomplishments of the 2018 summer magnetron R&D program was the driving of a warm RF Niobium cavity by a 2.45-GHz magnetron, demonstrating injection lock and filament control. This successful test is a proof-of-concept of magnetron control while providing accelerating voltage to a warm, non-superconducting conducting cavity.

A. Test Setup

Previous experiments have demonstrated injection locking on a 2.45-GHz commercial magnetron with a matched load. The test stand for those experiments³ was modified to accommodate a niobium RF cavity, as shown in Figure 7.

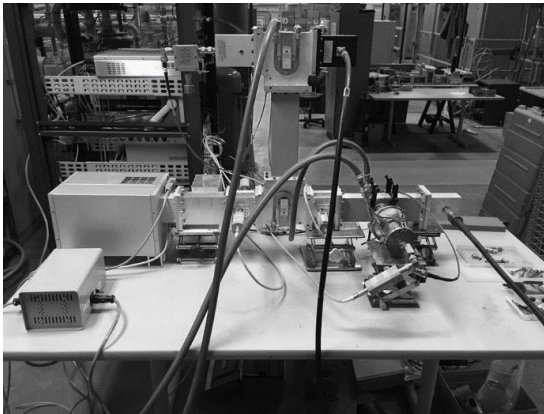


FIG. 7. Photograph showing warm niobium cavity test stand.

In the foreground of the figure are the filament control box and a copper cavity (the actual experiment used a Niobium cavity, as the copper cavity needed to be retuned). The filament control box allows for control over magnetron noise. We demonstrated locking of the magnetron on an injected signal, typical of particle accelerator operation, which requires a synchronized signal.

For the experiment, the magnetron radiates into the WR340 waveguides until the signal is directed to a doorknob-style antenna transmitter, which resonates with the copper cavity. Meanwhile, injected signal from a signal generator is sent to the magnetron and locks the frequency.

Circulators and directional couplers prevent reflections from going back to the source, and reflections are absorbed by matched loads to keep the back injection signal clean and stable. It was found during calibration of these circulators and couplers that for the circulators, using an open-to-the-air port provided greater RF absorption with less reflection than a waveguide-to-coax transition with a 50- Ω load attached.

IV. DRIVING THE RF CAVITY

A niobium cavity with resonant frequency of 2448.6 MHz was driven by an injection-locked magnetron with filament control. Using an injection signal and microwave frequency counter, the injection signal can be tuned until it is within pulling range of the magnetron, and with the filament power supply off, noise reached levels lower than 50 dB of the operating signal, with a sideband of 80 kHz from the injection lock frequency.

For the test of the niobium cavity, the power loss of the internal accelerating field can be found using the definition of quality factor of the cavity $Q = \omega U/P_{loss}$, where U is the stored energy in the cavity.

The power leaving the cavity P_{out} is related to the quality at the exit port Q_{ext2} by

$$P_{out} = \frac{\omega U}{Q_{ext2}}$$

while the power loss due to the field in the cavity P_0 is given by

$$Q_0 = \frac{\omega U}{P_0} \implies P_{out} = \frac{Q_0 P_0}{Q_{ext2}}.$$

We can see here that the power loss is a function of the qualities Q_0 and Q_{ext2} . Determining of the Q_0 of the cavity was done under room-temperature conditions using a two-port S_{21} measurement (meaning a ratio of the signal exiting port 2 relative to the input at port 1) on a network analyzer. Once the coupling coefficients β_1 and β_2 and the quality of the load Q_L are known, we can obtain Q_0 from $Q_0 = Q_L(1 + \beta_1 + \beta_2)$.

We first obtain the loaded quality Q_L from $Q_L = \frac{f_0}{BW}$, where f_0 is the resonant frequency of the cavity and BW is the bandwidth (in our experiment, -3dB). The coupling coefficient β_1 is found from the one-port S_{11} measurement on the input coupler, with

$$\beta_1 = \frac{1 - \frac{S_{11,on}}{S_{11,off}}}{1 + \frac{S_{11,on}}{S_{11,off}}}$$

for $0 < \beta_1 < 1$. The on refers to the S_{11} measurement at the resonant frequency of the cavity while off refers to the same measurement off resonance. β_2 is found from $\beta_2 = \frac{Q_0}{Q_{ext2}}$

The quality at the exit port Q_{ext2} is still desired. We can find it from

$$Q_{ext2} = \frac{4\beta_1}{1 + \beta_1} Q_L \times 10^{-S_{21}/10}.$$

Overall, this resulted in a cavity quality $Q_0 = 2902$. Finally, the power loss in the cavity is given by

$$P_0 = \frac{Q_{ext2} P_{out}}{Q_0}. \quad (6)$$

In this experiment with the niobium cavity, P_{out} was found by measuring the signal at the exit port of the cavity and cavity power was found to be $P_0 = 740 \text{ W}$, demonstrating driving of the niobium cavity. Hence resistive losses in the system were high, and the cavity reached temperatures of 71°C , as the cavity was air-cooled.

V. 1497-MHZ TEST STAND

Muons, Inc. (Batavia, IL) is currently designing a low eddy current 1497-MHz magnetron for driving RF and SRF cavities, and planned tests will demonstrate RF amplitude control over magnetron noise with an impedance matched load.¹¹ Features enabling this control will include back injection phase lock as well as filament, anode current, and trim magnetic field controls.

The mechanical design of the test stand made with AUTOCAD, and the stand will be made of lightweight aluminum from 80/20 structural components, while also being compatible with an existing klystron experiment at Jackson Lab (Figure 8). In addition, to prevent disruptions of the sensitive magnetic field within components of the ferrite circulators, the fasteners on the top half of the frame are nonmagnetic.

The design and construction of this test stand with the planned low-level RF controller is a major step in research and development, and because the stand is mobile it can be moved to accommodate future experiments.

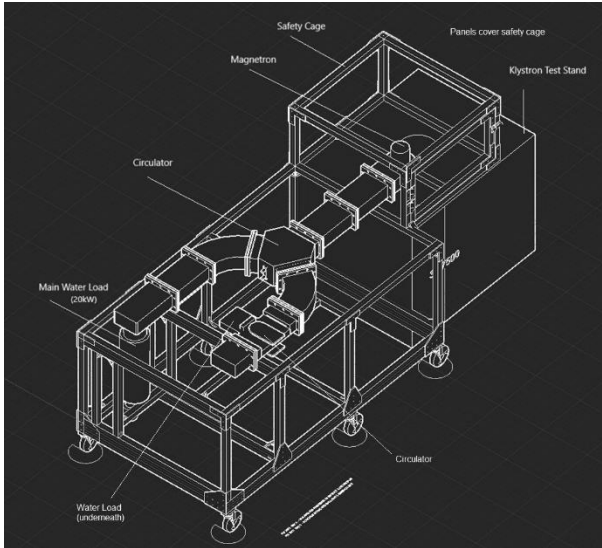


FIG. 8. Design of the 1497-MHz magnetron test stand.

VI. CONCLUSION

To progress magnetron R&D towards CEBAF source replacement, a test stand was developed for the 1497-MHz magnetron experiment. This test stand will support an experiment with control over magnetron noise, gain, and frequency pushing and will be ready for coming magnetrons this fall. A bipolar amplifier-type power supply is being refurbished to be suitable for modulating a pair of trim coils for the 2.45-GHz magnetron external magnetic field. Optimization of a trimming magnetic field system requires improvements in power supply efficiency and lowering coil inductive losses, and a model for calculating loss in the coils due to the proximity effect was tested. Design, calibration, and assembly of RF components for the injection lock and filament control to a 2.45-GHz commercial magnetron was completed as well as a successful test driving a warm niobium cavity.

Future trim coil analysis will be needed to optimize magnetron magnet systems of various designs, taking into account mutual and self-

inductive losses, hysteresis of the core, and proximity effects. The results of the 2.45-GHz experiment with a niobium cavity and trim coil is a critical step for the proof-of-principle for the accelerator RF source replacement. The findings will allow Jefferson Lab researchers to optimize 1497-MHz and 915-MHz magnetron experiments demonstrating magnetron capability as an efficient RF source in high-energy particle physics.

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To Protect a Scumbag: Larry Flynt as Metaphor for First Amendment Media Cravenness

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Abstract

*Politics makes strange bedfellows, yet the traditional media still refuse to join with Larry Flynt as he repeatedly defends First Amendment principles. Over three decades, he has launched multiple First Amendment assaults in the courts with two making it to the Supreme Court. He lost one case there and won the other, a landmark free expression decision involving protections for parody in *Hustler v. Falwell* in 1988. The high court refused to consider two other challenges. Larry Flynt is an unlikely and difficult person to defend, let alone admire. Supporters and opponents are appalled at his profession and the way he objectifies and treats women. Still, he is an unrepentant defender of the Bill of Rights. "If the First Amendment will protect a scumbag like me," Larry Flynt observed, "it will protect all of you." So, why has the traditional media in recent years failed to support both Flynt and the ideals that have animated American journalists for well over two centuries and motivated them to defend their constitutional rights in the courts until the last four decades? Declining ad revenues, plummeting*

circulation and viewership, and a changing media and political environment are possible reasons. But there may be other explanations that have nothing to do with Larry Flynt and everything to do with eroding support for constitutional protections and liberties. This study examines several famous free press challenges, such as the Pentagon Papers, the New York Times v. Sullivan case, and Watergate, when the media did rise to the constitutional challenge, and others, such as restrictions on news helicopters after September 11 and constitutional access to the battlefield, when it did not.

“If the First Amendment will protect a scumbag like me it will protect all of you.”

– Larry Flynt

Larry Flynt claims, “Politics is my hobby.” And that hobby makes strange bedfellows, but the traditional media simply refuses to climb under the constitutional covers with Flynt as he repeatedly defends First Amendment principles.¹ In two decades, Flynt has launched multiple First Amendment assaults in the courts, two making it to the Supreme Court. He split there, winning one and losing the other. The Supreme Court refused to consider the other two.² Larry Flynt is an unlikely and difficult person to defend, let alone admire. Both opponents and supporters are appalled at his profession and the way he objectifies and treats women. Still, he is an unrepentant defender of the Bill of Rights. “If the First Amendment will protect a scumbag like me,” Larry Flynt remarked, “it will protect all of you.”

So, why has the traditional media in recent years failed to support both Flynt and the ideals that have animated American journalists for well over two centuries and motivated them to defend their constitutional rights in the courts? Declining ad revenues, plummeting circulation and viewership, and a changing media and political environment are possible reasons. But there may be other explanations that have nothing to do with Larry Flynt and everything to do with eroding support for constitutional protections and liberties. The purpose of this study is to examine several famous free press challenges, such as the Pentagon Papers,³ the *New*

¹ “Politics makes strange bedfellows,” Charles Dudley Warner, *My Summer in a Garden and Calvin, A Study of Character* (1870). Warner was a journalist, essayist, novelist, and friend of Mark Twain, with whom he coauthored *The Gilded Age: A Tale of Today* (1873).

² To be argued before the Supreme Court, a minimum of 4 Justices must agree to hear the case.

³ *New York Times v. United States*, 403 U.S. 713 (1971).

York Times v. Sullivan case,⁴ and Watergate, when the media did rise to the constitutional challenge, and others, such as restrictions on news helicopters after September 11 and constitutional access to the battlefield, when it did not.

I. Larry Flynt

“Majority rule only works if you’re also considering individual rights. Because you can’t have five wolves and one sheep voting on what to have for supper.”

– Larry Flynt

Flynt launched his porn empire after purchasing his mother’s bar in Dayton, Ohio, in 1965, eventually opening the first of several Hustler Clubs in the state, all featuring nude female dancers.⁵ To promote his clubs, he published the *Hustler Newsletter* in early 1972, building on its success two years later with the nationally distributed and sexually explicit *Hustler* magazine. In 1971, Flynt purchased nude sunbathing photos of former first lady Jacqueline Kennedy Onassis from a paparazzi photographer and published them in 1975, cementing his fame and wealth.⁶

Flynt has appealed to the Supreme Court four times, including his most famous case on free expression, *Hustler v. Falwell*.⁷ In 1981, the Supreme Court refused to consider Flynt’s appeal alleging prosecutorial misconduct in a case charging him with obscenity and organized crime.⁸ Flynt lost another libel case before the high court after Kathy Keeton, the

⁴New York Times v. Sullivan, 376 U.S. 254 (1964).

⁵Flynt served stints in the U.S. Navy and Army, faking his birth certificate to enlist in the latter. While serving as a radio operator on the *USS Enterprise*, he was on duty when the carrier was assigned to recover astronaut John Glenn after orbiting the earth in *Friendship 7* in February 1962.

⁶In the midst of one of many court battles over obscenity, this one in Georgia, Flynt was shot and paralyzed by a would-be assassin, who escaped. White supremacist Joseph Paul Franklin, a serial killer, eventually admitted to the attempted murder, although he was never charged. Franklin was later executed for eight murders in Missouri. Flynt opposed Franklin’s execution. Spending his life in a wheelchair did prompt Flynt to quip in a dispute with then-California governor Gray Davis, “I may be paralyzed from the waist down, but ... I’m not paralyzed from the neck up.”

⁷Hustler Magazine, Inc. v. Falwell, 485 U.S. 46 (1988).

⁸Flynt v. Ohio 451 U.S. 619 (1981) *cert. denied*. He was originally found guilty and sentenced to between 7 and 25 years in jail, eventually serving under a week. A movie was made of the case, “The People vs. Larry Flynt,” which earned Woody Harrelson an Oscar nomination for his portrayal of Flynt. Flynt had two roles in the film, one as the judge that sentenced him and one as a juror.

girlfriend of *Penthouse* publisher Bob Guccione, sued Flynt and *Hustler* for libel in Ohio, narrowly missing the statute of limitations deadline. Keeton refiled the suit in New Hampshire, which Flynt contested, but the Supreme Court upheld it.⁹ The libel case was his most lurid and certainly most profane Supreme Court appearance, prompting Chief Justice Warren Burger to find him in contempt of court after he screamed several obscenities at the court and its Justices during oral arguments.¹⁰ Flynt's fourth Supreme Court case involved his lawsuit against Secretary of Defense Donald Rumsfeld to embed *Hustler* reporters with the American military forces during the second Gulf War. The Court refused to hear Flynt's appeal.¹¹

II. Literature Review

“You know, everybody believes in free speech until you start questioning them about it.”
– Larry Flynt

In “Casablanca,” after Rick Blaine famously shot Major Strasser, Captain Renault turned to his underling and told him, “Round up the usual suspects.”¹² Over the course of U.S. history, those press suspects have been easy to locate: they were in the vanguard of fights over the First Amendment and other constitutional challenges. Now, it seems, those usual suspects—the *New York Times*, ABC News, CNN, the *Washington Post*, the *Chicago Tribune*, NBC News, and others—have gone missing and some unusual suspects, such as Larry Flynt and *Hustler*, have taken their place. Scholar Clay Calvert found it intriguing that Flynt and not the more famous press institutions chose to fight for constitutional access to the battlefield access, not once, but twice. “The mainstream media,” Calvert stated, was “apparently afraid of compromising its relationship with government sources” (Calvert, 147, 152).

Scholar Jonathan Sterne blamed this on deadlines and the very nature of the modern reporter's job. “The system of [governmental] lying, PR, and misinformation depends upon reporters doing their jobs just as they are supposed to,” he wrote, adding this allowed “the U.S. government's PR apparatus [to] exploit the institutions and routines of the press...” (Sterne, 2005). Sterne was harsh in his criticism of the media.

⁹ Keeton v. Hustler, 465 U.S. 770 (1983).

¹⁰ The charge was later dismissed.

¹¹ Flynt et al. v. Rumsfeld, Sec. of Defense 335 F.3d 697 (D.C., Cir. 2004) *cert. denied*, 125 S. Ct. 313 (2004).

¹² Humphrey Bogart, Conrad Veidt, and Claude Rains, respectively.

“As it stands, the press has essentially become a client of the federal government for its political news” (Sterne, 2005).

Micah Holmquist, writing in *Press Action*, saw nothing particularly insidious at work, but agreed with Sterne that deadline pressure forced reporters to rely on certain sources and that professional convenience and speed guaranteed that reporters would be very reluctant to “burn” a source. However, he criticized reporters, especially in the Washington press corps, for not developing stories on their own and creating an issue agenda independently. Reporters, he declared, “will ask ‘tough’ questions about matters that have already been discussed on cable news and talk radio by people who are nearly exclusively interested in promoting the Democrats or Republicans” (Holmquist, 2005). There is no risk in that of alienating sources, Sterne reasoned. “It is easy to applaud the mainstream media for taking a critical stance,” he added, “now that less is at stake and their own hides are no longer on the line” (Sterne).

Scholar William Lee considered there was no incentive on the part of the mainstream press, with their reporters already embedded (part of the system), to assist those in the disadvantaged media, risking at the very least having to share or lose slots in pools or embedded units. Lee added there was probably a patriotic reluctance on the part of the press to file lawsuits during wartime as well (Lee, 743, 745).¹³ In addition, one media lawyer contended, “[I]t is obviously a question of some access is better than none, and people are reluctant to lose what they have by becoming rabble-rousers” (Lee, 751). But the *Times*, the *Post*, ABC, and the others have historically been agitators, and in fact that is the very role demanded of them by the Constitution.

III. Landmark Cases

“Any time there’s a scandal, we always try and get involved.”
– Larry Flynt

The pivotal case in libel law is *New York Times v. Sullivan*, stemming from an advertorial in the *Times* by the Committee to Defend Martin Luther King and the Struggle for Freedom in the South. It detailed civil rights abuses in Alabama and solicited financial contributions (New

¹³ Lee also suggested, rather vaguely, that the media attempted to “infuse First Amendment values into its bargaining with the military” over access, without discussing how this might be accomplished. He also took a poke at the media’s pretensions, quoting a parody headline, “Media Executives Chafe at War Department Restrictions on Reporting: ‘Why Can’t We Go on Doolittle Raid Over Tokyo?’ Demands Head of ABC News,” 751.

York Times v. Sullivan, 1964).¹⁴ L.B. Sullivan, an elected police commissioner in Montgomery, Alabama, filed a civil libel suit against the *Times* and the individuals who signed the ad, mainly black activists and clergymen. There were several factual mistakes in the ad. King had been arrested four times, not seven. The Alabama State College dining hall was not “padlocked,” and there were no attempts to starve students into giving up. Nine student leaders were expelled from college for demanding to be served at a Montgomery courthouse lunch counter, not for singing at the state capitol. Police did not ring the campus. The *Times* advertising staff could have checked the facts against the newspaper’s own stories on the situation but chose not to (Middleton et al., 103). A Montgomery Circuit Court ruled against the *Times*, which appealed. The Alabama Supreme Court upheld the lower court, prompting the *Times* to appeal to the U.S. Supreme Court.

The Supreme Court in *Sullivan* ruled unanimously that the First Amendment protects even false and defamatory criticism of governmental officials. Writing for the Court, Associate Justice William Brennan stated that public officials must “establish that defamation has been published with knowing falsity or reckless disregard for the truth.” At issue, he wrote, was “a profound national commitment to the principle that debate on public issues should be uninhibited, robust, and wide-open, and that it may well include vehement, caustic and sometimes unpleasantly sharp attacks on government and public officials.” Without the protection of the First Amendment, Associate Justice Brennan worried that potential governmental critics would not speak up out of fear of the costs of losing or even defending a libel suit. Speech would be “chilled.” Associate Justice Brennan insisted (*New York Times v. Sullivan*).¹⁵

Advertisements were protected in the same way as news stories, the Court determined. The Court devised what has become known as the actual malice standard. To prevail, a defendant must prove a defendant knew the statement was false or was reckless in making it. According to Middleton et al., “The *Times*’s failure to check the ad against [its own] news stories might be evidence of negligence, but it did not demonstrate recklessness” (Middleton et al., 104-05).

¹⁴ The *Chicago Tribune* and the American Civil Liberties Union filed amicus briefs with the Court supporting the *Times*.

¹⁵ In recent years, the late Associate Justice Antonin Scalia and Associate Justice Clarence Thomas expressed their willingness to overturn the *Sullivan* decision, although there seems to be little other support on the Supreme Court to do so.

Pentagon Papers

On June 13, 1971, the *New York Times* began publishing excerpts from a 7,000-page, 47-volume classified Pentagon history of the Vietnam War that would become known as the Pentagon Papers. Five days later, the *Washington Post* followed suit. The top-secret document was leaked by a Department of Defense analyst, Daniel Ellsberg, enraged and disillusioned by its findings and what he saw as the hypocrisy and venality of American leaders (Folkerts & Teeter, 501). Among the findings: President Johnson was secretly planning to escalate U.S. military intervention in Vietnam, despite public assurances to the contrary, and the Gulf of Tonkin affair, the incident that provided the Congressional authorization for escalation, was almost entirely fabricated.

The U.S. Justice Department sought a pair of injunctions to suspend publication against the *Post* and *Times*, citing national security. The U.S. Court of Appeals for the Second Circuit in New York granted the injunction, forcing the *Times* to cease publication. However, the Court of Appeals for the D.C. Circuit refused to enjoin the *Post*. On appeal from Attorney General John Mitchell, the Supreme Court prohibited the *Post* from publishing. The newspapers appealed again and the Supreme Court agreed to decide the cases, consolidating them into one as *New York Times v. United States* (1971).

The high court granted expedited review and delivered its 6–3 decision in a week. It ruled that the First Amendment did not permit injunctions and that prior restraint was unconstitutional, allowing both newspapers immediately to resume publication. The Court was sharply divided and, unusually, nine separate decisions were delivered in the case. The pivotal statement of the Court ruling was that the government had not met its “heavy burden” of proof that an irreparable harm to U.S. interests would occur through publication and one that would justify overriding the constitutional presumption against prior restraint (Middleton et al., 60).

It was a defining precedent. There were clear cases that could justify prior restraint, Associate Justice Brennan wrote in concurrence, but since the Vietnam War had never been declared by Congress, then there could be no imminent danger. Three other justices said that Congressional action could have allowed an injunction against publishing top-secret materials. Only Associate Justices Hugo Black and William O. Douglas wrote that they could never imagine an instance in which prior restraint was constitutional.

Watergate and other scandals

In September 1971, burglars led by White House aide Howard Hunt broke into a Los Angeles psychiatrist's office seeking the medical records of Daniel Ellsberg, who leaked the Pentagon Papers (Folkerts & Teeter, 502). The burglary was approved by John Ehrlichman, one of Nixon's two principal aides. During the subsequent Watergate controversy, those L.A. burglars were found to be members of a White House-sponsored group colloquially known as the Plumbers, which attempted to accumulate information on Nixon's opponents. An official enemies list was even drawn up.

On June 17, 1972, burglars were caught breaking into Democratic National Headquarters in the Watergate office and residential complex in Washington, D.C. Behind the Pulitzer Prize-winning reporting of Carl Bernstein and Bob Woodward, the *Washington Post* doggedly followed the trail all the way to the White House and other recesses of government and for the longest time did so alone. The *Post* was sometimes ridiculed by public, government, and other media outlets. Within days of that break-in, Nixon's secret tapes would reveal that the president authorized a cover-up. Nixon was compelled by a unanimous Supreme Court to relinquish the tapes to Special Prosecutor Leon Jaworski (*Nixon v. U.S.*, 1974).¹⁶ Eventually, his presidency would collapse, and he would be disgraced, resigning in August 1974.

IV. September 11

“You have to be able to tolerate what you don't necessarily like so you can be free.”

– Larry Flynt

Within minutes of the first attack on September 11, 2001, news helicopters converged on the World Trade Center and the Pentagon. The skies were then emptied of civilian air traffic, including news helicopters, by the Federal Aviation Administration (FAA) on orders from the National Security Council (NSC). For over three months, news helicopters were forbidden to fly within 18 miles of the top 30 busiest U.S. airports and the cities surrounding them, which is considered Enhanced Class B airspace (FAA). Virtually the entire aviation community had returned to the nation's airspace long before complete access was restored

¹⁶ Then-Associate Justice William Rehnquist did not participate in the arguments or decision.

to news helicopters and, even then, significant restrictions were retained. U.S. airspace was gradually reopened over a period of weeks in late September and October 2001. However, flights into Enhanced Class B airspace by news helicopters were explicitly forbidden, despite the lack of statutory or regulatory authority. Student pilots, even, were permitted back into the restricted airspace, but not news helicopters. A typical Notice to Airmen, something pilots are required to consult prior to flight, was issued on October 17, 2001: “The following operations are not authorized under this provision (FDC1/1474) and remain prohibited from operating in Enhanced Class B Airspace: *News Reporting*...” (Focus on Remaining, 2001).¹⁷

Prior to 9/11, according to federal aviation regulations, the media were allowed into certain restricted airspace created by a procedure called temporary flight restrictions (TFRs) where the general flying community was barred. However, the U.S. Attorney General ignored all these exceptions in the wake of September 11 and, along with FAA officials ostensibly empowered to create TFRs, refused to give a full explanation, citing national security (Focus).¹⁸ While constitutionally problematic, TFRs can be quite effective. When the Murrah Federal Building in Oklahoma City, Oklahoma, was bombed in April 1995, a news helicopter from a local TV station was on the scene within minutes. It had time for only three circles of the building before the FAA instituted a TFR over the site that stayed in effect until the building was demolished a month later (McSkimming). In the wake of a killer tornado in Jarrell, Texas, on May 27, 1997, an approach control facility created an unauthorized TFR banning news helicopters from the vicinity of Ft. Hood’s Gray Army Airfield (Tatom).

Barbara Cochran, president of the Radio and TV News Directors Association, saw the ban on news helicopters as a possible assault on the First Amendment because restrictions “single out flights for the specific purpose of news reporting” and could not be “narrowly tailored to serve a compelling government interest” (Cochran). David Fidanque, director of the Oregon chapter of the American Civil Liberties Union, argued the restrictions amounted to unconstitutional prior restraint (Mayer). In addition, he suggested targeting pilot “journalists” smacked of content restrictions and seemed to violate the Supreme Court’s United Reporting Publishing admonition against viewpoint discrimination (Los Angeles

¹⁷ Emphasis added.

¹⁸ On October 30, 2001, a blanket, national TFR was promulgated by the FAA, forbidding pilots from flying within 10 nautical miles of nuclear power plants without actually telling them where those plants were located. Several days of confusion ensued before the TFR’s expiration.

Police Department v. United Reporting, 1999).¹⁹ No media organization objected or filed lawsuits, including the networks and their affiliates, the ones actually operating the barred news helicopters. The only groups objecting were pilot organizations, such as the Aircraft Owners and Pilots Association (AOPA). The *New York Times*, *Washington Post*, CBS—those usual suspects—were all missing.²⁰

V. Very Well, Alone

“We pay a price for everything to live in a free society. And what we pay for free speech is toleration. We have to tolerate things that we don’t necessarily like so we can be free.”

– Larry Flynt

Larry Flynt published an offensive, sophomoric, and satirical advertisement in *Hustler*, mimicking a famous Tanqueray series of ads with celebrities’ “first time” drinking the gin, the beginnings of his most famous and influential Supreme Court case. Flynt chose the Rev. Jerry Falwell for *Hustler*’s version, describing an incestuous relationship with Falwell’s mother in an outhouse—the minister’s sexual “first time.” At the bottom of the ad, a disclaimer was printed: “Ad parody—Not to be taken seriously” (Middleton et al., 2007).²¹ Falwell was not amused and sued for libel, intentional infliction of emotional distress, and invasion of privacy. The U.S. Court of Appeals for the Fourth Circuit rejected the libel and invasion of privacy claims but did rule that Falwell suffered emotional distress. Flynt appealed to the U.S. Supreme Court.

In its unanimous decision, the Court termed the ad “outrageous” and so obviously so that it was in the area of protected political opinion and not defamatory speech.²² Chief Justice William Rehnquist, who wrote the Court’s majority opinion, compared the ad to political cartoons

¹⁹ L.A. Police Dep’t. v. United Reporting Publ’g. Corp. 528 U.S. 32 (1999).

²⁰ Francis Gary Powers was the central figure in a Cold War drama, shot down in his U2 spy plane taking photographs of the Soviet Union military installations in May 1960. He was convicted of espionage but released 20 months later in a prisoner swap. He died while piloting a KNBC news helicopter in west Los Angeles on August 1, 1977. Powers lost control trying to avoid children during an emergency landing. His cameraman George Spears was also killed.

²¹ The two principals in the Supreme Court case later became friends, according to Flynt after Falwell’s death. “I always appreciated his sincerity, even though I knew what he was selling, and he knew what I was selling.” Larry Flynt, “The Porn King and the Preacher: How I Found Myself in Jerry Falwell’s Embrace,” *Los Angeles Times*, May 20, 2007, online.

²² The decision was 8-0; Associate Justice Anthony Kennedy recused himself.

that were a long-standing tradition in American journalism. Satire of that sort was by necessity “intentionally injurious” and a “weapon of attack, of scorn and ridicule and satire,” the Chief Justice emphasized. Rehnquist rejected an “outrageousness” standard as a way to judge political speech, noting this view “runs afoul of our longstanding refusal to allow damages to be awarded because the speech in question may have an adverse emotional impact” (*Hustler v. Falwell*, 2283). Motive was also dismissed. The First Amendment, Chief Justice Rehnquist believed, protects those things “done with motives that are less than admirable” (*Hustler v. Falwell*, 2285). The Court rejected the emotional distress claim as well.

But Flynt and *Hustler* fought this battle alone. Other members of the mainstream media, either fearful of the power of the Moral Majority that Falwell headed or worried about how unseemly it would be to be associated with such a pornographic periodical and its publisher, did not join with *Hustler* in the lawsuit. A number of them—such as *The New York Times*, CBS, and NBC, along with the American Civil Liberties Union, and Reporters Committee for Freedom of the Press—did file friend of the court (*amicus curiae*) briefs with the Court supporting *Hustler* without joining the lawsuit.

Weinberger

Larry Flynt has taken on the Department of Defense twice, arguing the existence of a constitutional right of access to the battlefield.²³ Flynt v. Weinberger was filed by the publisher of *Hustler* during the U.S. invasion of Grenada in 1983 (*Flynt v. Weinberger*, 1984).²⁴ The district court dismissed the case, deciding that wars of that sort were short in duration and unlikely to be repeated in the future. The district judge stated, however, “[T]here is support for the proposition that the press has at least some minimal right of access to view and report about major events that affect the functioning of government, including, for example, an overt combat operation. As such, the government could not wholly exclude the press from a land area where a war is occurring that involves this country” (*Flynt v. Weinberger*, 142). Flynt further cited a Depart-

²³ For all the Flynt battlefield challenges, see: *Flynt v. Weinberger* 588 F. Supp 57 (1984); *Flynt v. Weinberger* 246 U.S. App. D.C. 40 (D.C. Cir. 1985); *Flynt v. Rumsfeld*, 335 F.3d 697 (D.C. Cir. 2004); and *Flynt et. al. v. Rumsfeld, Sec. of Defense*, 335 F3d 697 (D.C. Cir. 2004), *cert. denied*, 125 S.Ct. 313 (2004).

²⁴ See: Thomas Terry, “Of Foreign Fevers, Shot, and Shell: Constitutional Rights of Media Access to the Battlefield after *Flynt v. Rumsfeld*.” *National Security and Armed Conflict Law Review*, Vol. V: 2014-2015, 95-116.

ment of Defense Directive 5122.5 (Enclosure 3) that regulates media access and promises “open and independent” reporting. Flynt claimed this amounted to content-based prior restraint and was unconstitutional. His appeal was denied by the Court of Appeals for the D.C. Circuit in an unsigned opinion (Flynt v. Weinberger, 1985). The Court ruled that different wartime circumstances might justify various restrictions on media access on a case-by-case basis.

Rumsfeld

In late 2001, scarcely two months after September 11, Flynt took to the courts again, this time preemptively. He asked permission from the Department of Defense for a reporter to accompany Special Forces hunting for Al Qaeda suspects in Afghanistan. Assistant Secretary of Defense for Public Affairs Victoria Clarke did not flatly reject Flynt’s request but did rebuff his request to travel with Special Forces. She suggested *Hustler* reporters could ride along with air strikes and humanitarian airdrops and interview soldiers. Clarke provided contact information for the U.S. Fifth Fleet, reiterating the military’s adherence to Department of Defense Directive 5122.5 (Enclosure 3) that stated, “open and independent reporting shall be the principal means of coverage of U.S. military operations.” The directive noted that pools might be a temporary expedient and that access to Special Forces might be limited (*Nation Magazine v. Department of Defense*, 1991). Rather than take advantage of the Defense Department offers, Flynt filed suit on November 16, 2001, challenging the military on constitutional grounds, claiming historic media access to the battlefield and demanding that a *Hustler* reporter be embedded with U.S. troops in Iraq and Afghanistan. He charged that Directive 5122.5 and Enclosure 3 were content-based prior restraint.

The federal District Court for the District of Columbia denied Flynt’s motion for a preliminary injunction, noting that the war in Afghanistan “would have to await the development of a fuller record” (*Nation Magazine v. Department of Defense*, 1). Flynt was not deterred. He filed an amended complaint with the District Court, claiming a constitutional right of access, something that Directive 5122.5 (Enclosure 3) failed to recognize. The District Court again spurned Flynt. The court ruled that the military had not actually made a final decision regarding Flynt’s request and that he could not demonstrate any “concrete injury” (*Nation Magazine v. Department of Defense*, 2).

Flynt appealed to the U.S. Court of Appeals for the D.C. Circuit. On February 3, 2004, a three-judge panel of the court affirmed the lower

court's ruling. Judge David Sentelle, writing the unanimous opinion, unequivocally rejected Flynt's constitutional claim to be embedded. "There is nothing in the Constitution, American history, or case law that requires the military to provide the media with access to combat," Sentelle stressed. A contradictory, yet tantalizing, glimmer of hope was left by Sentelle. "The Government has no rule—at least as far as Flynt has made known to us—that prohibits the media from generally covering war," Sentelle wrote (*Flynt v. Rumsfeld*, 403). He added, somewhat in contradiction to the overall opinion, "Although it would be dangerous, a media outlet could presumably purchase a vehicle, equip it with necessary technical equipment, take it to a region in conflict, and cover events there. Such action would not violate Enclosure 3 or any other identified DoD rule" (*Flynt v. Rumsfeld*, 400-01).²⁵ The Supreme Court refused to take the case on October 12, 2004, in response to Flynt's further appeal (*Larry Flynt et al. v. Rumsfeld*, 2004).²⁶

VI. Discussion

"[Y]ou got to stand in a courtroom and listen to a judge sentencing you to 25 years in prison before you realize that freedom of expression can no longer be taken for granted."

– Larry Flynt

Undoubtedly, the media calculated the odds of winning a lawsuit, Flynt's perceived reputation, the effect on their public image at a time of patriotic fervor, and the likely widespread popularity of leaders and policies in wartime and found the odds too long. Flynt, and the others in what could be generously called the alternative media, had little to lose, since they were already largely frozen out of Pentagon coverage arrangements (itself problematic constitutionally and beyond the scope of this study). Their audiences were far narrower and less likely to be adversely affected by public sentiment ... and unable to make sufficient noise. And Flynt could safely be dismissed and ignored, given his public reputation.

²⁵ Judge Sentelle was previously hostile to press access rights, writing the unanimous decision in *Center for National Security Studies v. Department of Justice*, 331 F.3d 918 (D.C. Cir. 2003). The decision upheld the constitutionality of a federal Freedom of Information Act exemption that allowed withholding the names of suspects detained after September 11, 2001.

²⁶ Associate Justice Hugo Black in his concurrence in the *Pentagon Papers* case wrote, "And paramount among the responsibilities of a free press is the duty to prevent any part of the government from deceiving the people and sending them off to distant lands to die of foreign fevers and foreign shot and shell." *New York Times v. United States* 403 U.S. 713, 717 (1971).

Moreover, to amplify the complaints of the smaller, disreputable, and less visible media would have given them credibility and lent weight to their arguments, all of which could have rebounded to the mainstream media's disadvantage. It would also have raised the very issues of access the big players were calculatedly trying to avoid.

The traditional media may have decided not to hazard their dwindling resources to support both Flynt and a cause that bucked patriotic frenzy, especially in a highly charged competitive media marketplace and while facing a disintegrating business model. The combined ad revenue for the three big networks continues to plummet in the migration of content to digital platforms and social media. Newspapers are slashing newsroom staffs as ad revenues slump and readers abandon print for the web. Even *The New York Times* is not immune, cutting staff and reducing salaries in recent years. The *Los Angeles Times* newsroom staff is on its way to being half the size of a decade ago. The *Chicago Tribune* has declared bankruptcy, the two Detroit newspapers no longer produce print editions every day, and the *Seattle Post-Intelligencer* has gone entirely online. Only the *Washington Post* has thrived and expanded, although it is in a unique position, relying on Amazon billionaire Jeff Bezos's deep pockets. At the same time, Google, BuzzFeed, Huffington Post, Politico, Twitter, Facebook, and other on-line monoliths continue to hire and expand their news products, only somewhat slowed by the economy, fueled by ad revenues and audiences switching to the Internet. Other competitive pressures also play an important, perhaps pivotal, role in picking (or not picking) constitutional fights. If one newspaper or network loses access to a pool or embedded coverage, readers and viewers may well abandon it and search out a news outlet with access. Advertisers would then further shift spending to where the readers and the viewers are.

Perhaps it is much simpler still. Maybe it is all about personalities and a new generation of mainstream media leaders without the same journalistic commitment, chutzpah, or principles. At the *Post*, Publisher Fred Ryan is not Katherine Graham. Nor is Martin Baron a Benjamin Bradlee. At CBS, perhaps David Rhodes is no William Paley. At the *Times*, it could be that Arthur Gregg Sulzberger is not his grandfather, Arthur Ochs Sulzberger, Sr. Nor is Dean Baquet another Abe Rosenthal. Rupert Murdoch and Jeff Bezos are not Joseph Pulitzer or even William Randolph Hearst. And, certainly, none are Larry Flynt. It is not just the top editors and owners. Dan Rather, Geraldo Rivera, Janet Cooke, Jayson Blair, and Claas Relotius left under various clouds of disgrace and professional failures. The only cloud Edward R. Murrow was ever under was the tobacco haze he created himself, the sea spray made by Walter Cronkite's sailing yachts, and the helicopter wash generated by

Richard Nixon's presidential helicopter after being hounded out of office by the reporting of Woodward and Bernstein.

In fairness, in prior decades, with robust and readership/viewership and stock prices less of a worry, news executives may have had the luxury to tilt at journalistic windmills. Fighting the good fight now may no longer be worth it financially. This is, of course, an insult to the First Amendment and the Framers who bridled under British press restrictions and enshrined press rights, responsibilities, and obligations at the very heart of our constitutional system. It could be the waning of idealism as well. The 1960s were a time of political and ideological ferment, from the Civil Rights and anti-war movements to the women's and environmental movements. Perhaps the mainstream media is just reflective of the increasing complacency, selfishness, and vacuousness of its generation. The fire in the belly is no longer there in a world of iPads, YouTube, Facebook, World of Warcraft, Twitter, Tinder, Netflix, Amazon and ... the list goes on. It may be the audience's hedonism, not Flynt's debauchery, that is triumphing.

There is also the issue of "being judged by the company you keep." It is conceivable that the *New York Times*, *Wall Street Journal*, Fox, *Newsweek*, and NBC News are just uncomfortable fraternizing with *Hustler* and its often coarse and abrasive publisher. They may plausibly worry about a backlash from certain conservative and religious organizations that might support a constitutional challenge—or at least not oppose it—but cannot countenance mainstream media's judicial cohabitation with Flynt and *Hustler*. This is not an altogether unlikely scenario: the American Civil Liberties Union in the late 1970s lost many members and considerable financial support when it defended the Nazis' constitutional rights to march in Skokie, Illinois, home to a substantial number of Holocaust survivors.

There is also the (implausible) possibility the mainstream media simply disagrees with the existence of a constitutional right to the battlefield or believes such a claim is so unlikely to prevail that financial resources would be better expended elsewhere. Perhaps the press also thinks news helicopters are a bane on civil society. Whatever the reason(s), the mainstream media has shied away from courtroom constitutional challenges. And finally, the consolidation of media into fewer and fewer hands and into ever larger corporations, many with only peripheral historic connection with media, has been debilitating to the journalistic will to challenge the political and financial elites and status quo. This reason may be the most compelling, the most obvious, and the most chilling.

VII. Conclusions

“If you're not going to offend somebody you don't need the First Amendment.”

– Larry Flynt

What does this controversy mean? The world is a much more dangerous place post-September 11, that is, if you are an enemy in America's global war against Al Qaeda and Isis and others of that ilk. The U.S. has launched two wars, one in Afghanistan and the other in Iraq. The Iraqi war was justified on faulty intelligence. The human and material costs, and the effect on America's international prestige, have been enormous. And yet the press did not inquire too closely into the rationales for the wars at their outset, climbing eagerly onto the jingoistic bandwagon. It, too, was “shocked and awed.” Congressional opposition was tepid at the outset as well. America's reputation as a swashbuckling, loose cannon internationally is enhanced by its soldiers' behavior at Abu Ghraib and the treatment of prisoners at Guantanamo Bay, where American constitutional niceties are sidestepped because prisoners are kept outside the reach of the Bill of Rights. Revelations of secret C.I.A. prisons in Europe further tarnished America's reputation. Secret Foreign Intelligence Surveillance court rulings and massive monitoring by the National Security Agency of cell phone and text conversations keep Americans suitably intimidated, oblivious, or uncaring. Again, Flynt weighed in, observing, “Privacy is not explicitly spelled out in the Constitution as freedom of speech is in the First Amendment.”

What is the media's role? Edward R. Murrow put it most aptly when taking on Sen. Joe McCarthy while much of the country kept silent in fear and in ignorance at what was at stake. He could be speaking about the media's responsibilities to a global community today.

We can deny our heritage and our history, but we cannot escape responsibility for the result. There is no way for a citizen of a republic to abdicate his responsibilities. As a nation we have come into full inheritance at a tender age. We proclaim ourselves—as indeed we are—the defenders of freedom, wherever it continues to exist in the world. But we cannot defend freedom abroad by deserting it at home
(Murrow, 1954).

The media argue they are a surrogate for American citizens. If so, they need to take up the judicial cudgel in tandem with Larry Flynt. But if the press refuses to regain its long-standing watchdog role, who or

what will put American policies, foreign as well as domestic, under a microscope? Does any other entity in our system have the resources to hold government accountable? Will government officials behave as responsibly if they are reasonably certain nobody is looking over their shoulders? The *Washington Post*, *Time*, CNN, and the *Boston Globe* in the past have taken on the full brunt—and fury—of governmental and White House opposition and not inconsiderable public and Congressional opposition. They stood up for what their editors and publishers regarded as a core Freedom of the Press issue: no matter what, government cannot tell the press what to publish and what not to publish. During Watergate, Executive Editor Ben Bradlee backed his reporters and behind him stood the publisher of the *Post*, Katherine Graham, who put the credibility and the very existence of her newspaper at risk more than once. Arthur Ochs Sulzberger, Sr. repeatedly took the same stance and risk at the *Times*. William Paley and CBS News supported Murrow in the face of considerable national and political contentiousness.

If *The New York Times* and *Washington Post* were presented with the Pentagon Papers today, would they act the same way? Or would they meekly return the documents to the Pentagon? Would CBS News today allow Murrow free rein to take on McCarthy? Would Watergate have remained simply a second-rate burglary? Would legendary *New York Times* journalist Harrison Salisbury still divine a nobility and an important constitutional role for the press? Or is the press treatment of Julian Assange and Wikileaks and Edward Snowden more instructive? These are troubling questions, and the post-September 11 record is not encouraging. Perhaps we would be wise to look to Larry Flynt, not in admiration, but for advice and warning. “[A] democracy can’t exist without free speech and the right to assemble,” Flynt observed. “And that’s what Americans tend to forget . . . They’re born into a culture where they take all of their freedoms for granted.”

“Alas, the storm is come again! My best way is to creep under his gabardine; there is no other shelter hereabouts: misery acquaints a man with strange bed-fellows. I will here shroud till the dregs of the storm be past.”

– William Shakespeare²⁷

²⁷The Tempest, Trinculo, Act II, Scene 2, li. 1125-29.

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Reviewing the Beck Depression Inventory on Its Psychometric Properties

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Abstract

The Beck Depression Inventory (BDI) is one of the most popular instruments in clinical practice and research. Practitioners often use the BDI to screen for depression and to assess the severity of depressive symptoms. Researchers often use the BDI to study depression in various populations, such as college students, adolescents, and individuals who abuse substances. In this test review, we explored the literature on the BDI's score reliability and the validity of its uses. Strengths of the BDI include high internal consistency and test–retest reliability, strong content validity, easy and cheap administration methods, and considerable convergent validity evidence. Weaknesses include high face validity (which allows clients to “fake” scores) and unrepresentative norm samples. There are gaps in the literature in regards to criterion-related and divergent validity evidence and test bias among people aged 60 to 80 years. Until researchers further investigate these areas, we cannot make a full judgment of the BDI. However, for

now, the BDI seems to be an appropriate instrument for the screening and researching of depression.

In 1961, Beck et al. published the Beck Depression Inventory (BDI) as a tool to improve accuracy in diagnosing major depressive disorder (MDD). Beck et al. (1961) originally created the BDI by observing clinical populations for the “attitudes and symptoms displayed frequently by depressed psychiatric patients and infrequently by nondepressed psychiatric patients” (Beck et al., 1988, p. 79). Although Beck et al. (1961) originally created the BDI for clinical diagnosis (Hatzenbuehler et al., 1983), Beck et al. (1996b) now discourage against diagnosing MDD with the BDI. Today, clinicians often use it to screen for MDD and to assess the severity of depressive symptoms. Researchers also often use the BDI to study MDD in several populations, such as college students (Villatte et al., 2017), adolescents (Khesht-Masjedi et al., 2017), and individuals who abuse substances (Moore et al., 2016). Indeed, the BDI remains one of the most popular instruments in clinical practice and research.

The aim of this review is to explore the literature on the effectiveness of the BDI as a screening and research tool of MDD. To do so, we will first provide a description of the BDI by exploring its administration and scoring procedures. Next, we will evaluate the BDI on its technical adequacy by exploring its score reliability and the validity of its uses and interpretations. We will conclude with our final commentary and evaluation of the BDI.

Test Description

The BDI is a psychometric instrument that is “designed to measure the severity of depressive symptoms in adolescents and adults” (Whisman & Richardson, 2015, p. 898). The current version of the BDI is composed of 21 multiple-choice items that range from 0 to 3 in intensity. The 21 items of the BDI are categories of common symptoms of MDD (Beck et al., 1961, 1988). The BDI was updated in 1976 as the BDI-IA and again in 1996 as the BDI-II. Because both the BDI-IA and BDI-II are copyrighted, we cannot include items from these versions in this review. However, the Appendix includes the original BDI (Beck et al., 1961), which is the only version that is not copyrighted.

Construct

According to the authors, the BDI-II measures MDD (Beck et al., 1996b). MDD “is the most common form of mental illness” (Portnoff et al., 2017, p. 22) and affects approximately 300 million people around the globe (World Health Organization [WHO], 2018). MDD is characterized by a depressed mood (e.g., feels sad, empty, or hopeless) that occurs almost every day for the duration of at least 2 weeks (American Psychiatric Association [APA], 2013). MDD substantially impairs a person's functionality in daily life, as it often lowers motivation and reduces quality of life (Høifødt et al., 2013). It is, however, very treatable for most people, as multiple treatment options exist, such as psychotherapy and medication (WHO, 2018).

Purpose

Although clinicians sometimes use the BDI-II for diagnosis (Jackson-Koku, 2016; Konstantinidis et al., 2011), Beck et al. (1996b) cautioned against the practice (Smarr & Keefer, 2011). Rather, the BDI is to operate as a screening tool by helping the clinician identify the *severity* of an individual's depression. The scores from the BDI can help the clinician make a treatment plan or a diagnosis when further knowledge is acquired.

Theoretical Foundation

Originally, Beck et al. (1961) created the BDI by observing clinical patients rather than by relying on any etiological theory. However, Beck is a proponent of the cognitive model of depression (Beck, 2008), and it is likely that Beck had this model in mind when he created the BDI (Jackson-Koku, 2016). According to this model, depressive disorders are due to cognitive biases and dysfunctional beliefs (Beck, 2008). Today, the BDI-II is composed of items that match the diagnostic criteria for depression according to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed. [DSM-IV], APA, 1994; 5th ed. [DSM-V], APA, 2013; Beck et al., 1996a).

Population

The BDI-II is designed for use on individuals ranging in age from 13 to 80 (Pearson, 2018). In 1996, Beck et al. used normative samples of adolescent and adult psychiatric outpatients and college students to create the BDI-II (Erford et al., 2016; Smarr & Keefer, 2011). As such, a

clinician or researcher should use caution when administering the BDI-II in a population outside of these groups.

Methods of Administration

Originally, Beck et al. (1961) created the BDI to be professionally administered by a trained interviewer (e.g., a clinical psychologist). However, the BDI-II is usually self-administered today (Edelstein et al., 2010). When the BDI-II is self-administered, it usually takes someone 5 to 10 minutes to complete (Jones et al, 2005; Smarr & Keefer, 2011). However, when the BDI-II is orally administered by a trained interviewer, it takes about 15 minutes.

Unlike its predecessors, the BDI-II has three administration formats: web-based, computerized, and paper-and-pencil (Smarr & Keefer, 2011; Pearson, 2018). A psychologist can administer the paper-and-pencil format to either a group or an individual (Smarr & Keefer, 2011). Several studies indicate that the different methods of administration are equally credible (Carlbring et al., 2007; Holländare, et al., 2010; Naus et al., 2009; Schulenberg & Yutzenka, 2001). Because the BDI-II is usually administered by the client himself and there are three administration formats, the BDI-II is a convenient tool for clinicians or researchers to use.

Scoring

The BDI-II consists of 21 items on a 4-point scale ranging from 0 for *symptom not present* to 3 for *extreme form of each symptom* (Smarr & Keefer, 2011). Because the BDI-II does not have any subscales, to calculate a total score the clinician or researcher only needs to sum the responses. Total scores can range from 0 to 63, with higher scores indicating more severe depression. Although there are no *actual* cutoffs for diagnosis (Smarr & Keefer, 2011), Beck et al. (1996b) offered the following suggestions to interpret the scores from the BDI-II: 0 to 13 for minimal depression, 14 to 19 for mild depression, 20 to 28 for moderate depression, and 29 to 63 for severe depression. Clinicians usually only use raw scores, coupled with these suggested categories, to interpret the BDI-II (Erford et al., 2016).

Technical Adequacy

Item Creation Procedures

Beck et al. (1961) originally constructed the BDI by observing depressed patients in clinical settings. After they compared their observations with the psychiatric literature, they grouped the symptoms into 21 categories. Each category referred to a specific behavior or characteristic that they believed was central to depression. Originally, they did not rely on any etiological theory regarding depression, but rather created each item to reflect a specific behavioral manifestation of depression.

The 21 categories were mood, pessimism, sense of failure, lack of satisfaction, guilty feeling, sense of punishment, self hate, self accusations, self-punitive wishes, crying spells, irritability, social withdrawal, indecisiveness, body image, work inhibition, sleep disturbance, fatigability, loss of appetite, weight loss, somatic preoccupation, and loss of libido (Beck et al., 1961, 1988). Beck and colleagues then included 4–5 self-evaluative statements for each category. Beck et al. (1961) assigned numerical values from 0 to 3 to each statement to indicate the level of severity. Several categories had two alternative statements that Beck and colleagues assigned the same weight.

Beck and colleagues published the BDI-IA in 1979 to eliminate “alternate wordings of the same responses and [to avoid] double negatives” (Beck et al., 1988, p. 80). In the BDI-IA, alternative responses were reduced, or the wording was changed, for 15 items (Beck et al., 1988). For the remaining 6 items (irritability, appetite, crying, fatigability, weight loss, and loss of libido), the alternative responses remained the same (Beck et al., 1988).

Although the BDI-IA was better than the original BDI (Beck et al., 1996a), it had a few critics (e.g., Moran & Lambert, 1983). One criticism was that the BDI-IA only met 6 out of the 9 diagnostic criteria for depression, according to the DSM-IV. Another criticism was that the BDI-IA did not include any items on psychomotor activity and agitation (Beck et al., 1996a).

To address these criticisms, Beck et al. (1996b) published the BDI-II. In the new version, Beck and his associates added items that were aligned with DSM-IV criteria, such as agitation, concentration difficulty, and worthlessness (Beck et al., 1996a). They also removed 3 categories—weight loss, body image change, and somatic preoccupation—from the BDI-II and changed the wording of several items. Only 3 items retained their same wording—punishment feelings, suicidal thoughts or wishes, and loss of interest in sex (Beck et al., 1996a). Finally, in the new version, the participant is to reflect on their symptoms for the last 2

weeks instead of the last week to better align with the DSM-IV. Although these changes were originally meant to better align with the DSM-IV, they have remained consistent with the DSM-V as well.

Norms

In 2000, Kendall and Sheldrick analyzed all treatment outcome studies that had been published between the years 1988 and 1997 in the *Journal of Consulting and Clinical Psychology*. The BDI was the most common instrument used in all studies. Out of the various studies that Kendall and Sheldrick analyzed, there were a total of 10 studies where the researchers included their normative samples. In 8 of the published studies, the normative population was undergraduate students. Most of the samples consisted of undergraduate students from the United States, but 3 studies had samples that consisted of undergraduates from Canada. In 3 of the studies the researchers included the percentage of race. The common races in these studies were White (79–96%), Asian (0–14%), Black (0–3%), and Hispanic (0–3%). In one study, the researchers had a small percentage of East Indian individuals (3%). Two researchers had a norm that consisted of adolescents. Females overpopulated all but one of the normative samples, with a mean of approximately 71% (Kendall & Sheldrick, 2000). Also, the mean age of the undergraduate normative samples ranged from 18.5 to 21.8 years. Most of the normative samples had BDI scores lower than 9 and the highest was 10.58.

Reliability

Internal consistency

Beck and his colleagues published an article that reviewed the psychometrics of the BDI after 25 years of its use (Beck et al., 1988). To calculate the internal consistency of the BDI, Beck et al. (1988) used data from 25 articles. They found “for psychiatric populations, the nine coefficient alphas ranged from 0.76 through 0.95, and the mean coefficient alpha was 0.86. Within 15 nonpsychiatric samples, the mean alpha was 0.81; the range was from 0.73 to 0.92” (Beck et al., 1988, p. 83). The stability of the BDI created some issues because the instrument itself is used to assess the intensity of depression in the individual taking it. The BDI score of the depressive individual is supposed to decrease through any means of treatment. Beck et al. (1988) used data from 10 studies to produce a Pearson product-moment correlation coefficient. In those individuals who had been hospitalized for depression, the coefficients ranged from 0.48 to 0.86, and for individuals in the research who had not

been hospitalized for depression, there were coefficients that ranged between 0.60 and 0.83 (Beck et al., 1988). In the research that was published in the 10 studies, there was an average length interval of 4.25 weeks. With the average length of time within the 10 studies and the high coefficients of the non-hospitalized participants, the data show that there is notable stability of the BDI.

Test–retest reliability

Although some studies indicate that test–retest coefficients (r) can be as low as 0.44 (e.g., Cukrowicz & Joiner, 2007), meta-analyses on BDI score reliability show that the average coefficient ranges from 0.720 (Yin & Fan, 2000) to 0.75 (Erford et al., 2016), with an average time lapse of six weeks. Although these average coefficients are “acceptable” because the BDI-II is not used for clinical diagnosis, studies that report reliability coefficients are rare, as Yin and Fan (2000) reported that 80.1% of the studies they reviewed did not include any. More studies are needed to determine the test–retest reliability of the BDI-II.

Validity

In psychometrics, “validity always refers to the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of interpretations and actions based on test scores” (Messick, 1989, p. 5). Similar to a court case, validity is an argument that someone makes by acquiring evidence (Warne, 2018). As evidence accumulates, the argument is strengthened. If there is enough validity evidence, then it is clear that test scores should be interpreted and used in the manner that the authors of the test proposed (Messick, 1989). In psychometrics, there are 13 types of validity evidence: concurrent, consequential, construct, content, convergent, criterion-related, divergent, external, face, incremental, internal, postdictive, and predictive. In this section, we will review the validity evidence for the BDI. Because several of these types are “part of” or similar to other types, we will not review the evidence for construct, concurrent, and external validity.

Convergent validity

This type of validity “is evidence that shows that the test score correlates with other outcomes or measures that it is theorized to correlate to” (Warne, 2018, p. 2). There is substantial evidence to indicate that the BDI is a credible measure of MDD. The BDI positively correlates with other measures of depressive symptoms, such as the Patient Health Questionnaire-9 ($r = 0.77$; Kung et al., 2013), the Reynolds Adolescent Depression Scale ($r = 0.84$; Krefetz et al., 2002), the Geriatric Depression

Scale ($r = 0.78$; Snyder et al., 2000), and the Hamilton Depression Rating Scale ($r = 0.73$; Beck et al., 1988). As such, there is considerable evidence supporting the claim by Beck et al. (1996b) that the BDI measures MDD (Smarr & Keefer, 2011).

Divergent validity

This type of validity examines criteria that a test score should not correlate to. If correlations are low or negative, then there is high divergent validity evidence (Warne, 2018). Although research on the divergent validity of the BDI is rare, there is evidence showing that the BDI can distinguish between anxiety and depression (Coles et al., 2001) and that it can discriminate between patients diagnosed and those not diagnosed with MDD (Arnarson et al., 2009). In regards to divergent validity, there is an extensive gap in the literature, though, and further research is needed in this area.

Criterion-related validity

This type of validity is the correlation between the test scores and other measures or outcomes of the same construct (Warne, 2018). To test for criterion-related validity, Sprinkle et al. (2002) administered the BDI-II to their clients and also diagnosed them using the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I; Spitzer et al., 1990), which is a structured interview that enables clinicians to make standardized and accurate diagnoses of mental disorders. In their sample, Sprinkle et al. (2002) found that the clients' BDI-II scores were positively correlated ($r = 0.83$) with the number of depressive symptoms, indicating that 68.89% of the BDI-II's variance was shared with the SCID-I variance. Although one study is not conclusive, the results from Sprinkle et al. (2002) show that the BDI is an effective measure of MDD.

Content validity

This type of validity is an examination of the relevancy of an instrument's content (Warne, 2018). In support of the BDI-II, its content is based on the diagnostic criteria listed in the DSM-IV. As such, it naturally has high content validity. However, some clinical psychologists believe that item 21 (loss of interest in sex) is irrelevant for adolescents (Osman et al., 2004), which is problematic because the BDI-II is meant for people aged 13 and above (Pearson, 2018). Overall, though, the BDI-II has items that are relevant to a diagnosis of MDD.

Face validity

This type of validity examines if items *appear* to measure the construct (Warne, 2018). Although the BDI-II has high face validity, this is not necessarily a good thing, as some researchers question if face validity is a “real” type of validity (Royal, 2016). Because of its face validity, “the BDI-II items can be 'faked' (good/bad) quite easily” (Osman et al., 2004, p. 122). This is problematic because clients often lie in psychotherapy, which can have detrimental effects on the therapeutic process (Blanchard & Farber, 2016). Further, individuals sometimes lie for court cases, which would be problematic for judicial decisions. As such, the BDI-II would likely be improved if items were less obvious or if there were a “lie scale,” similar to the Minnesota Multiphasic Personality Inventory (MMPI-2). However, either option would be difficult to do, because making items less obvious might interfere with item alignment with DSM criteria and including a “lie scale” would substantially increase the amount of items in the test.

Incremental validity

Incremental validity is defined as, “one test having more explanatory power, or variance, than another test” (Burneo et al., 2016, p. 395). The BDI-II was measured against the MMPI-2 in a population of individuals with neurological afflictions, to assess the likelihood of over- or underendorsing items. Scales 2, F, Fb, L, and K from the MMPI-2 were specifically selected because of their relationship to the measures of the BDI-II (i.e., Scale 2 directly relates to depression and the others are validity scales). The statistical analysis of the scales above (2, F, Fb, L and K), showed that “...Scale 2 accounted for 36.9% of variance followed by scale Fb, which explained an additional 17.6% of variability in BDI-II scores” (Burneo et al., 2016, p. 395). Burneo et al. (2016) reported that the “MMPI-II Scale 2 detected a significantly higher frequency of depressive symptoms than the BDI-II” (p. 395). This finding does not negate the BDI-II’s ability as a measurement scale as a whole because it is only applicable for the observed population of individuals with neurological afflictions. However, the data collected from this sample population show that it is possible for the BDI-II to misattribute the severity of symptoms.

Internal validity

This type of validity is evidence that the test structure aligns with theory (Warne, 2018). Factor analyses on the BDI-II generally show that it contains two factors: Somatic-Affective and Cognitive (e.g., Arnau et

al., 2001; Beck et al., 1996b; Steer et al., 1999; Storch et al., 2004; Whisman, Perez, & Ramel, 2000). However, Dozois et al. (1998) reported that the two factors were Cognitive-Affective and Somatic-Vegetative. Regardless, the two-factor structure of depression is in line with theory, as MDD has both cognitive and somatic symptoms (APA, 2013).

Consequential validity

This type of validity is an examination of the psychological, social, and economic consequences of using a test (Warne, 2018). Similar to face validity, there is debate about whether consequential validity is a “real” type of validity (Mehrens, 1997). However, it is still important to discuss the consequences of test use (Shepard, 1997). To evaluate the consequential validity evidence of the BDI, we will separate it into three sections: psychological, social, and economic consequences.

Psychological consequences. There is evidence indicating that merely completing the BDI may negatively affect one's mood (Mark et al., 1991; Sharpe & Gilbert, 1998). That is, the BDI may reinforce negative attitudes towards oneself, and thus it may worsen depressive symptoms when compared with others who do not take the test (Mark et al., 1991) or do so over a period longer than two weeks (Sharpe & Gilbert, 1998). However, several studies show that repeatedly administering the BDI over several weeks may actually *lower* depression scores (e.g., Ahava et al., 1998; Choquette & Hesselbrock, 1987; Hatzenbuehler et al., 1983). Therefore, the reported results from Mark et al. (1991) and Sharpe and Gilbert (1998) may not be credible.

Social consequences. Several studies indicate that there is a social stigma towards depression (e.g., Barney et al., 2006; McNair et al., 2002; Oakley et al., 2012; Sirey et al., 2001). Depressed people report that disclosing a diagnosis of MDD could potentially have an impact on employment (Roeloffs et al., 2003), friendships (McCann et al., 2012, or romantic relationships (Issakainen, 2013). As such, scores from the BDI could adversely influence an individual's life. However, this potentially negative effect is because of stigma towards diagnosis rather than the BDI itself.

Economic consequences. The BDI-II is relatively cheap to purchase, as it costs only \$60 to buy 25 forms (Pearson, 2018). This low price benefits the client because it decreases the cost of administration. However, any price for a diagnostic tool of depression would likely be less than leaving MDD untreated, as MDD is one of the most expensive diseases in the world (Berto et al., 2000; Sobocki et al., 2006). MDD taxes the American government and its citizens approximately \$210 billion each year (Greenberg et al., 2015). Therefore, the BDI is likely worth the expense.

Postdictive validity

Postdictive validity is the ability of a measurement scale to measure something that occurred in the past (Warne, 2018). The original BDI required participants to endorse items based on symptoms from the week prior to assessment. The BDI-II has participants look back an additional week (2 weeks) while endorsing the 21 items. This ability for the BDI or BDI-II to possess adequate postdictive validity is determined upon the individual's recollection of their symptoms. If an individual has difficulty remembering their symptoms from the previous week or two, then the BDI will not produce sufficient information for the participant.

Predictive validity

As postdictive validity is the ability of a test to measure things from the past, predictive validity is the ability of the test to measure things to come. Although research on the predictive validity of BDI-II scores is rare, there is some evidence showing that the BDI-II can possibly predict suicide attempts (Green et al., 2015). Also, because the BDI-II is based on the DSM-IV criteria for MDD, it naturally can predict a future diagnosis of the disorder (Nuevo et al., 2009).

Investigations of Bias

In psychometrics, testing bias is defined as a higher likelihood for someone to score higher or lower on a test because of group membership. Researchers have investigated whether the BDI-II shows bias towards college students, adolescents, and females; however, there is not much data on the BDI being used on individuals 60–80 years of age. Gatwood-Colwell et al. (1989) used the BDI on 51 participants with a mean age of 70.2 years. The sample consisted of both white males and females and Mexican-American males and females. The results stated, "...the internal consistency coefficient for the Beck scale was indicated by a Cronbach alpha of .80 ... in a concurrent validity test, significant Pearson product-moment coefficient ($p < .05$) of .79 was obtained on the Beck's scale..." (Gatwood-Coldwell et al., 1989, p. 1165). Gatwood-Colwell et al. (1989) performed an analysis of variance to identify differences between the men and women and the Mexican-American and white groups. There were not any specific differences between the Mexican-American and white groups ($p = .97$) or between the men and women groups ($p = .68$) (Gatwood-Coldwell et al., 1989). The data show that the BDI can be used for individuals 60 or more years old without bias. The small sample size used in the study above limits the generalizability of the results, so additional research on the BDI and its use is needed for sufficient external validity.

Commentary and Judgment

The purpose of the BDI-II is to provide a quantitative assessment of the intensity of depression. The design of the test provides a deeper analysis of a patient's depression, as it can track changes over time and provide an objective measure for assessing improvement and judging the effectiveness of certain treatment methods. Among clinicians, it is one of the most popular instruments for screening depression because it is fast and inexpensive to administer, especially when compared to the MMPI-2 (Peterson et al., 2014). Because it seems effective at identifying individuals with depression (Nuevo et al., 2009), it is also popular among researchers of MDD (Kendall & Sheldrick, 2000).

Strengths of the BDI include high internal consistency and test-retest reliability, strong content validity, easy and cheap administration methods, and considerable convergent validity evidence. Weaknesses include high face validity (which allows clients to “fake” scores) and unrepresentative normative samples. There are gaps in the literature in regards to criterion-related and divergent validity evidence and test bias among people aged 60 to 80. Researchers need to investigate these areas more fully before we can make a full judgment of the BDI. However, as there is considerable evidence supporting the BDI, it seems logical to tentatively conclude that the BDI is an effective screening tool of MDD (Furlanetto et al., 2005).

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Appendix

1961 Version of the Beck Depression Inventory

A (Mood)

- | | |
|----|--|
| 0 | I do not feel sad |
| 1 | I feel blue or sad |
| 2a | I am blue or sad all the time and I can't snap out of it |
| 2b | I am so sad or unhappy that it is very painful |
| 3 | I am so sad or unhappy that I can't stand it |

B (Pessimism)

- 0 I am not particularly pessimistic or discouraged about the future
- 1 I feel discouraged about the future
- 2a I feel I have nothing to look forward to
- 2b I feel that I won't ever get over my troubles
- 3 I feel that the future is hopeless and that things cannot improve

C (Sense of Failure)

- 0 I do not feel like a failure
- 1 I feel I have failed more than the average person
- 2a I feel I have accomplished very little that is worthwhile or that means anything
- 2b As I look back on my life all I can see is a lot of failures
- 3 I feel I am a complete failure as a person (parent, husband, wife)

D (Lack of Satisfaction)

- 0 I am not particularly dissatisfied
- 1a I feel bored most of the time
- 1b I don't enjoy things the way I used to
- 2 I don't get satisfaction out of anything any more
- 3 I am dissatisfied with everything

E (Guilty Feeling)

- 0 I don't feel particularly guilty
- 1 I feel bad or unworthy a good part of the time
- 2a I feel quite guilty
- 2b I feel bad or unworthy practically all the time now
- 3 I feel as though I am very bad or worthless

F (Sense of Punishment)

- 0 I don't feel I am being punished
- 1 I have a feeling that something bad may happen to me
- 2 I feel I am being punished or will be punished
- 3a I feel I deserve to be punished
- 3b I want to be punished

G (Self Hate)

- 0 I don't feel disappointed in myself
- 1a I am disappointed in myself
- 1b I don't like myself
- 2 I am disgusted with myself
- 3 I hate myself

H (Self Accusations)

- 0 I don't feel I am any worse than anybody else
- 1 I am very critical of myself for any weakness or mistakes
- 2a I blame myself for everything that goes wrong
- 2b I feel I have many bad faults

I (Self-punitive Wishes)

- 0 I don't have any thoughts of harming myself
- 1 I have thoughts of harming myself but I would not carry them out
- 2a I feel I would be better off dead
- 2b I have definite plans about committing suicide
- 2c I feel my family would be better off if I were dead
- 3 I would kill myself if I could

J (Crying Spells)

- 0 I don't cry any more than usual
- 1 I cry more than I used to
- 2 I cry all the time now. I can't stop it
- 3 I used to be able to cry but now I can't cry at all even though I want to

K (Irritability)

- 0 I am no more irritated now than I ever am
- 1 I get annoyed or irritated more easily than I used to
- 2 I feel irritated all the time
- 3 I don't get irritated at all at the things that used to irritate me

L (Social Withdrawal)

- 0 I have not lost interest in other people
- 1 I am less interested in other people now than I used to be
- 2 I have lost most of my interest in other people and have little feeling for them
- 3 I have lost all my interest in other people and don't care about them at all

M (Indecisiveness)

- 0 I make decisions about as well as ever
- 1 I am less sure of myself now and try to put off making decisions
- 2 I can't make decisions anymore without help
- 3 I can't make any decisions at all any more

N (Body Image)

- 0 I don't feel I look any worse than I used to
- 1 I am worried that I am looking old or unattractive
- 2 I feel that there are permanent changes in my appearance and they make me look unattractive
- 3 I feel that I am ugly or repulsive looking

O (Work Inhibition)

- 0 I can work about as well as before
- 1a It takes extra effort to get started at doing something
- 1b I don't work as well as I used to
- 2 I have to push myself very hard to do anything
- 3 I can't do any work at all

P (Sleep Disturbance)

- 0 I can sleep as well as usual
- 1 I wake up more tired in the morning than I used to
- 2 I wake up 1-2 hours earlier than usual and find it hard to get back to sleep
- 3 I wake up early every day and can't get more than 5 hours of sleep

Q (Fatigability)

- 0 I don't get any more tired than usual
- 1 I get tired more easily than I used to
- 2 I get tired from doing anything
- 3 I get too tired to do anything

R (Loss of Appetite)

- 0 My appetite is no worse than usual
- 1 My appetite is not as good as it used to be
- 2 My appetite is much worse now
- 3 I have no appetite at all any more

S (Weight Loss)

- 0 I haven't lost much weight, if any, lately
- 1 I have lost more than 5 pounds
- 2 I have lost more than 10 pounds
- 3 I have lost more than 15 pounds

T (Somatic Preoccupation)

- 0 I am no more concerned about my health than usual
- 1 I am concerned about aches and pains or upset stomach or constipation or other unpleasant feelings in my body
- 2 I am so concerned with how I feel or what I feel that it's hard to think of much else
- 3 I am completely absorbed in what I feel

U (Loss of Libido)

- 0 I have not noticed any recent change in my interest in sex
- 1 I am less interested in sex than I used to be
- 2 I am much less interested in sex now
- 3 I have lost interest in sex completely

Survey of First Experience of Sexual Intercourse: Revisited

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ABSTRACT

In this study, gender and religiosity are examined as predictors of perception of first experience of sexual intercourse in a Salt Lake Community College (SLCC) sample. Results are compared with similar studies conducted in 1988 and 2009. A number of questions about the respondents' first sexual encounter were assessed, including the timing of sexual debut, the type of contraception used (if any), and affectual response to the encounter. Researchers found that gender acted as a major predictor of responses, as in previous years. Women were more likely to express negative associations with sexual debut, reporting fewer orgasms and more frequent feelings of shame, remorse, or disappointment afterward. Women were also likely to enter their first experience against their will (8.9%). When asked whether respondents would change the experience, wishing to have a consensual first encounter arose as a more prominent trend than in previous years. Religiosity acted as a predictor of sexual affect in fewer cases than with gender. Those with high religiosity were less likely to use contraception. Those high-religiosity individuals who did use contraception less frequently used standard condoms and more frequently used intrauterine

devices (IUDs). High-religiosity respondents reported feeling guilt after their first experience more frequently than their low-religiosity counterparts. Over time, respondents were more likely to report being in long-term or exclusive relationship than in previous years.

THE RESEARCH PROBLEM

In this study, the researchers examine the influence of gender identity and religiosity on reflections on first sexual experiences in the Intermountain West. Results are compared with responses from two similar studies conducted in 1988 and 2009.

Introduction

One's first experience of sexual intercourse is widely recognized as an important milestone. For most, heavy emotions surround coital debut. Hence, the topic is often discussed in a research setting as a representation of changing social norms and sexual attitudes. In a 1988 survey, Stroub asked students from several colleges across the Intermountain West to reflect on their first sexual experiences. He focused primarily on differences in experience and affect based on sex. He found that women were much more likely than men to report negative reflections of their coital debut, both physically and psychologically. Women reported fewer orgasms and stronger feelings of remorse or misgivings than men.

James, Cunningham, and Blake later replicated Stroub's survey at Salt Lake Community College (SLCC) and compared the findings (2009). Although women still reported more negative reflections on their feelings after sexual debut, the gap between men and women's answers shrank. They also found an increase in the use of contraception, the most common method being condoms. These findings may be attributed to a gradual normalization of sex positivity for women.

Statement of Problem

The purpose of this study is threefold: to revisit the aforementioned past studies on sexual debut; to examine religiosity as a predictor of responses; and to update the survey's language and terminology to fit current research standards. To code respondents by religiosity, the researchers will use the Centrality of Religiosity Scale (Huber and Huber 2012).

Updating the language used in Dee Stroub's 1988 work will produce more inclusive and specific questions. This allows researchers to step outside the gender binary and use LGBTQ-inclusive word choice.

Moreover, updating the survey will fit current gender research standards and provide more precise data. A question asking respondents whether their encounter was consensual was also added to the survey.

Definitions

Religiosity, a key demographic collected in the survey, is “the centrality, importance, or salience of religious meanings in personality” (Huber and Huber 2012). In the employed Centrality of Religiosity Scale, respondents were rated from 1 to 5 based on a series of questions regarding religious belief, participation in religious activities, etc. Those with scores between 1 and 2.5 were labeled “low religiosity.” Those with scores between 2.5 and 5 were labeled “high religiosity.”

Each participant defined the term “sexual intercourse” as part of the survey. Using a modified question from the Kinsey Report, researchers asked each respondent to select which acts qualify as “sexual intercourse.” Allowing the respondent to use their own definition of sexual intercourse removed any confusion for the respondent about whether or not certain acts “qualify” as sexual intercourse.

Respondents were given the option to select nontraditional gender options in the survey. Options besides the traditional “male” or “female” included agender and nonbinary. Agender is defined as a lack of gender affiliation. Nonbinary refers to any gender identity lying outside of the traditional male and female.

Justification of Study

This study measured students’ responses periodically, tracking social change over time. Having a better understanding of current trends in normative behavior will expand on the understanding of sexual attitudes. The Salt Lake Valley offers a unique population because of its status as the headquarters for the Church of Jesus Christ of Latter-Day Saints (LDS or LDS Church). Utah has the highest LDS membership than anywhere else, at ~55% of citizens; Utah is also the most religiously homogeneous of any state (Pew Research, 2014). Leaders of the LDS Church strongly encourage members to practice sexual restraint by rejecting sexual temptations (Sumerau and Cragun 2015). Since Utah’s population is highly saturated with LDS members and church values, the cultural norms are strongly influenced by the LDS Church. Given that LDS practices encourage refrain from sexual thoughts or actions, it is of interest to what degree those practices influence the norms of our sample.

LITERATURE REVIEW

Stroub's findings do not stand alone in the literature surrounding sexual debut. Since Stroub's study in 1988, a myriad of other studies have pointed to the persisting gender discrepancies in pleasure and affect during sexual debut. Women are significantly less likely to report physical satisfaction than men during their first experience of vaginal intercourse (Higgins et al. 2010). They are consistently experiencing higher degrees of physical pain, coupled with fewer orgasms (Tsui and Nicoladis 2004).

Women and men also tend to differ in psychological experiences of sexual debut. In a series of case studies intended to decode the symbolism of virginity loss, women described their virginity as a gift, while men described it as a stigma (Carpenter 2002). This theoretical framework is unsurprising, given that women are more likely to report feeling sadness, guilt, or fear after losing their virginity (Guggino and Ponzetti 1997; Sprecher et al. 1995). Alternatively, men tend to report feeling more pleasure, both physiologically and psychologically (Sprecher et al. 1995).

It should be noted that the aforementioned studies tend to assume vaginal intercourse as the definition of sexual intercourse, even if not explicitly stated. Literature examining nonheterosexual debut are few and far between. In a systematic review of literature on sexual satisfaction, researchers did not cite sexual orientation as a commonly discussed predictor of sexual satisfaction in general, let alone during the first experience (del Mar Sánchez-Fuentes et al. 2013). This could be due to the greater availability of heterosexual respondents.

Another noteworthy predictor of sexual pleasure and affect during sexual debut is religiosity. According to an analysis of the Add Health Survey, adolescents who delayed initiating first sex commonly displayed a high degree of religiosity (Lammers et al. 2000). Higher religiosity at a younger age predicts future decisions to postpone sexual behavior into young adulthood, suggesting that the influence of religiosity on the timing of sexual debut is not bidirectional (Hardy and Raffaelli 2003). Religiosity also acts as a predictor for sexual pleasure and affect during sexual debut. Women with greater levels of religiosity tend to report less physiological sexual satisfaction at the time of debut and more guilt afterward (Higgins et al. 2010).

RESEARCH METHODS

Sampling Procedures

The population used for this study consisted of students enrolled at Salt Lake Community College (SLCC) in Fall Semester 2018 and Spring Semester 2019. Researchers collected demographic information (e.g., age, race, sex, gender identity, sexual orientation, religious affiliation, religiosity) for each respondent. The questionnaire was primarily derived from past studies regarding sexual debut (Stroub 1988; James et al. 2009). The remaining questions came from the Centrality of Religiosity Scale (Huber and Huber 2012), as well as new questions developed to fit current research.

Questionnaires were distributed across various SLCC general education classes anonymously for students who volunteered to participate. Surveys were built and distributed through Qualtrics, a software that ensures respondent information is kept confidential. No identifying personal information was collected from the students. Before entering the survey portal, students were shown a consent letter detailing the sensitive nature of the survey. Students were required to select “Yes, I consent and agree to complete this survey” before answering any questions.¹

Data Analysis

For analyzing the collected data, researchers used Qualtrics, STATA, and Microsoft Excel. A total of 578 students responded to the survey. Researchers used Qualtrics Data & Analysis to score religiosity, code qualitative responses, and code by gender. STATA was then used to test for statistical significance in comparing responses by gender and religiosity. Chi-square tests were used for nominal dependent variables, while one-way ANOVA tests were used for interval dependent variables. Microsoft Excel was used for comparing this dataset with older studies, creating tables, and making graphs.

DEMOGRAPHICS

Students responded to multiple demographic questions in the survey.² An *n* of 578 was used in these demographic representations. Of the

¹ Students were also informed that, while the questions focused on first sexual experience, there would be a separate section for those who hadn't had their first sexual experience. These responses will be examined in future research.

² Questions included age, sex, gender identity, race, ethnic identity, sexual orientation, relationship status, religious identity, parents' level of education, and household income.

demographics collected, gender identity and religiosity were the only variables used in data analysis thus far. Other demographics may be used in future endeavors with the dataset.

The majority of respondents were 18–24 in age (76%), female (73%), white (70%), and heterosexual (78%). The sample was mostly high-religiosity (61%), with the most commonly cited religion being LDS or Mormon. For a richer account of the demographics displayed in this sample, please see Appendix A.

RESULTS

In all of the tables below, asterisks are used to denote statistical significance between groups based on p-values. To see how p-values were determined for each variable type, refer to the methods section. The * denotes a p-value of $\leq .05$; ** denotes a p-value of $\leq .01$; and *** denotes a p-value of $\leq .001$.

At what age did you have your first experience of sexual intercourse?				
Year	Men	Women	Low Religiosity	High Religiosity
2019	17.65***	16.83***	16.49**	17.35**
2009	17.66	17.04		
1988	15.7	16.2		

Although the age of sexual debut increased between 1988 and 2009, no significant changes were observed in the last ten years. In 2019, men reported having their first experience of sexual intercourse one year later than women, on average. This change is on par with national data, since the age of sexual debut has increased gradually from 1982 to 2010 (Finer and Philbin 2014).

High-religiosity individuals were more apt to experience sexual debut at approximately one year older than their low-religiosity counterparts. This is consistent with other reports on the influence of religiosity on age at first sex (e.g., Lammers et al. 2000; Hardy and Rafaelli 2003).

Both men and women reported experiencing sexual debut with partners of an older age. While the average woman had her first encounter at 16.83 years old, her average partner was 18.66. The trend is mimicked in men to a slightly lesser degree (self 17.65; partner 18.36 years).

What was your partner's sex? ³						
Men's responses			Response	Women's responses		
1988	2009	2019		1988	2009	2019
96.19	93.79	96.00	Opposite sex	97.93	95.24	96.11
3.81	6.21	4.00	Same sex	2.07	4.33	3.89

Values reported as percentage of whole.

Although more respondents reported being nonheterosexual in 2019, they were almost equally likely to have an opposite sex partner in 2019 as in 1988. Considering that the average age of sexual debut in this survey was ~16.5 years old, and that lesbian or bisexual women report, on average, not knowing they are queer until 18 (Pew Research Center 2013), it is possible that a number of the respondents did not realize a nonheterosexual identity until after their first experience.

Was the encounter consensual?		
Response	Men 2019	Women 2019
Yes	98.00***	84.81***
No	1.00	11.31
I don't know	1.00	3.89

Values reported as percentage of whole.

This question was added in the 2019 survey, so previous data are not available. Women were over 10 times more likely than their male counterparts to enter their first experience without their consent.

How long did you know the person?						
Men's responses			Response	Women's responses		
1988	2009	2019		1988	2009	2019
12.90	14.69	7.00	<1 week	7.90	5.19	3.53
12.90	13.56	11.00	1–4 weeks	8.89	17.32	7.07
20.48	13.56	15.00	1–3 months	16.57	8.23	13.43
9.50	16.95	10.00	3–6 months	12.72	22.08	14.84
15.24	14.12	16.00	6–12 months	24.56	14.29	21.91
20.48	26.55	41.00	≥1 year	28.99	32.03	39.22

Values are reported as a percentage of the whole.

³ In 2019, the students identified their partner's sex from a selection of "male," "female," or "intersex." Responses were then coded into either opposite or same-sex manually. In previous years, students chose "same sex" or "opposite sex."

Consistently for men and women, the number of people who knew their partner for ≥ 1 year has steadily increased since 1988. Fewer respondents reported knowing their partner for < 1 week in 2019.

Would you describe the relationship as: (Check all that apply)						
Men's responses			Response	Women's responses		
1988	2009	2019		1988	2009	2019
44.28	42.94	42.86	Casual	22.78	16.88	31.16
26.67	30.51	42.86	Affectionate	37.57	38.53	44.57
20.48	19.21	30.61	Loving	23.96	34.63	36.59
12.38	16.95	33.67	Exclusive	24.56	38.96	46.74
10.00	12.43	22.45*	Long-term	24.26	36.80	37.32*
3.81	10.17	9.18	Marriage	8.58	9.52	9.42
8.09	5.08		Other	9.47	8.66	

Values are reported as a percentage of the whole.

Between 1988 and 2019, the number of men who reported being in a long-term or exclusive relationship increased over twofold. Most of this change took place in the last 10 years. Men were also more likely to describe the relationship as loving or affectionate than in previous studies. Women reported each descriptor (excluding marriage) at a higher rate than in previous studies. The largest change in women's responses was the rate at which they identified their relationship as casual. Whereas the number of "casual" responses decreased from 1988 to 2009, it nearly doubled between 2009 and 2019, with a net positive change. The number of exclusive relationships increased steadily from 1988 to 2019. The increase in other descriptors for women is moderate and steady.

The gap between men and women in responses to this question are most notable in their usage of "casual," "exclusive," and "long-term" to describe their relationship. Men reported "casual" at a higher rate than women. Women reported "exclusive" and "long-term" at a higher rate than men.

Although there were variations in low- and high-religiosity individuals' usage of the descriptors "exclusive" and "long-term" to describe their relationship, the only statistically significant difference observed was in their use of "marriage." High-religiosity individuals were over three times more likely than low-religiosity individuals to report having experienced sexual debut within the context of marriage.

How did religiosity affect responses?		
Response	Low Religiosity	High Religiosity
Casual	35.15	34.63
Affectionate	45.45	41.95
Loving	34.55	34.63
Exclusive	46.67	40.00
Long-term	30.91	34.63
Marriage	4.24**	13.17**

Values reported as percentage of whole.

For both men and women, entering the first experience “willingly” is hiking upward, while entering “eagerly” is trending slightly downward. Gaps between genders in responses to the 2019 survey arose in the categories “eagerly,” “against your will,” and “with misgivings. Men were more likely to report entering their first experience eagerly, while women were significantly more likely to report entering their first experience against their will or with misgivings.

Did you enter in the first sexual experience (Check all that apply)						
Men’s responses			Response	Women’s responses		
1988	2009	2019		1988	2009	2019
56.60	67.80	80.41	Willingly	51.80	67.97	73.31
53.80	50.80	45.36*	Eagerly	17.70	28.14	28.11*
1.40	0.56	1.03***	Against your will	7.10	5.63	8.9***
6.60	11.30	7.22*	With misgivings	28.70	17.32	20.28*
14.20	21.47	17.53	Fearfully	28.10	32.90	26.69

Values are reported as a percentage of the whole.

For the most part, the orgasm gap between men and women during sexual debut has stayed static since 1988. The only change in reported orgasms is that men are almost 10% less likely to report that their partner had an orgasm, and more likely to report either “no” or “I don’t know” in 2019. Whether the partner experienced orgasm is unknown in 1988, as the question was not asked.

Did you and your partner experience orgasm or climax with the first experience?						
Men’s responses			Response	Women’s responses		
1988	2009	2019		1988	2009	2019
80.00	77.40	67.01***	Yes, I did	12.40	15.58	12.46***
18.50	18.08	30.93	No, I didn’t	86.90	73.59	81.85
	3.39	2.06	I don’t know		9.96	5.69

–	42.94	35.05***	Yes, they did	–	74.89	74.38***
–	28.81	32.99	No, they didn't	–	7.79	11.74
–	26.55	31.96	I don't know	–	16.02	13.88

Values are reported as a percentage of the whole.

No major changes were observed between 1988 and 2019 in responses regarding emotional or physical pressure. However, it should be noted that women are still significantly more likely to report feeling pressured emotionally or physically into their first sexual experience.

Do you feel you were pressured emotionally or physically?						
Men's responses			Response	Women's responses		
1988	2009	2019		1988	2009	2019
11.90	14.69	13.4***	Yes, emotionally	41.70	29.44	32.74***
87.60	84.75	86.60	Not emotionally	56.50	80.00	67.26
11.10	13.56	9.28*	Yes, physically	18.30	17.75	19.93*
84.40	86.44	90.72	Not physically	79.60	82.68	80.07

Values are reported as a percentage of the whole.

Overall, the feelings described by respondents have changed in 12 descriptors for each gender. The 2019 responses expressed a greater range of emotions than in previous studies.

How would you describe your feelings afterwards (terms provided)?						
Men's responses			Response	Women's responses		
1988	2009	2019		1988	2009	2019
38.10	44.63	63.54***	Joy	22.20	32.90	35.97***
50.00	48.02	55.21*	Excitement	32.20	37.66	37.77*
13.80	13.56	9.38*	Fear	26.60	20.35	18.71*
17.18	19.21	18.75**	Guilt	42.60	29.44	39.21**
5.70	14.12	7.29	Remorse	13.60	18.18	20.5
14.80	18.08	15.63	Regret	30.50	27.27	28.06
4.80	13.56	14.58**	Shame	26.30	25.11	32.01**
37.10	33.33	40.63**	Fulfillment	15.40	20.03	40.63**
17.60	18.08	21.88*	Disappointed	35.20	32.90	35.25*
29.00	36.72	39.58***	Gratification	11.50	15.15	17.63***
48.10	51.98	60.42***	Satisfaction	21.60	28.57	36.33***
3.80	3.95	3.13*	Loneliness	13.90	10.82	14.39*
4.30	11.30	12.50**	Panic	14.50	15.58	23.02**

Values are reported as a percentage of the whole.

The gap in affective response to sexual debut between men and women remains striking. Women are experiencing more negative emotions and fewer positive emotions than men on average. Each response besides “panic” held significantly different frequencies in men and women.

How did religiosity affect responses?		
Response	Low Religiosity	High Religiosity
Joy	41.42	43.75
Excitement	42.01	41.83
Fear	13.61	19.23
Guilt	27.22**	39.90**
Remorse	15.38	18.75
Regret	24.85	25.00
Shame	23.67	31.25
Fulfillment	26.63	25.96
Disappointment	33.73	30.77
Gratification	21.89	24.52
Satisfaction	40.83	43.27
Loneliness	12.43	10.58
Panic	21.89	20.19

Values are reported as a percentage of the whole.

Although high and low religiosity individuals were mostly consistent in assessments of their feelings after their first experience, high religiosity individuals were significantly more likely to report feeling “guilt.” While “guilt” was the only statistically significant difference, other negative attributes (e.g., “remorse,” “regret,” “shame”) were used more often by high religiosity individuals.

Beforehand, did you and your partner discuss the possibility of pregnancy?						
Men’s responses			Response	Women’s responses		
1988	2009	2019		1988	2009	2019
30.90	25.42	35.05	Yes	44.90	37.23	34.16
68.10	72.88	64.95	No	54.70	60.61	65.84

Values are reported as a percentage of the whole.

No significant changes over time were observed, suggesting that communication about the risks of sexual intercourse is still minimal. Between 1988 and 2019, less than half of each cohort reported discussing the possibility of pregnancy before engaging in first sex.

Did you use any form of contraception?						
Men's responses			Response	Women's responses		
1988	2009	2019		1988	2009	2019
35.20	53.67	69.07	Yes	44.90	71.00	59.07
62.90	45.76	30.93	No	54.40	28.57	40.93

If yes, what kind?		
Response	Men 2019	Women 2019
Standard condom	87.35	88.06
Birth control pills	30.12	28.36
IUD	7.23	5.97
Other	6.62	7.46

Values are reported as a percentage of the whole.

Over time, men were much more likely to report using birth control in their first sexual encounter. Women, however, declined in their use of birth control. While the number of women using birth control is still higher than in 1988, it has declined since 2009.

No statistically significant differences emerged in contraceptive types between men and women. Standard condoms are, by and large, the most commonly used contraceptive method during sexual debut.

How did religiosity affect responses?		
Response	Low Religiosity	High Religiosity
Yes	67.65*	55.92*
No	32.35	44.08

How did religiosity affect responses?		
Response	Low Religiosity	High Religiosity
Standard condom	93.91**	81.36**
Birth control pills	26.96	32.20
IUD	2.61**	11.02**
Other	8.70	5.09

Values are reported as a percentage of the whole.

High religiosity individuals were significantly less likely to use birth control than their low religiosity counterparts. Those high religiosity respondents who did use contraception were more likely to use long-term planning types of contraceptives, namely IUDs. Low religiosity individuals were 10% more likely to use standard condoms.

Who do you think has the majority of the responsibility of providing birth control?					
Men's responses			Response	Women's responses	
2009	2019			2009	2019
36.16	17.53		Male	13.85	7.47
32.20	8.25		Female	57.57	11.39
28.25	74.23		Both	26.41	81.14

Values are reported as a percentage of the whole.

This question did not appear on the questionnaire in 1988, but was added in 2009. Researchers originally forced respondents to choose between “male” and “female,” not providing a “both” option. The group of respondents who reported “both” in 2009 wrote in their response next to the question, rather than using the provided responses. In 2019, seeing the demand for this option, researchers allowed respondents to say “both.” As anticipated, the bulk of respondents reported that both sexes are responsible for providing birth control. Of the respondents that did choose between male and female, they were more likely to assign responsibility to their own gender.

Compare the quality of your first experience with later experiences. (Check all that apply). First experience was more:						
Men's responses			Response	Women's responses		
1988	2009	2019		1988	2009	2019
33.80	41.81	36.99*	Exciting	16.30	28.14	20.27*
41.40	42.37	34.25*	Scary	61.20	62.34	45.95*
12.40	15.25	19.18	Fulfilling	4.40	8.66	9.46
20.00	19.77	35.62	Disappointing	41.40	36.36	49.95
17.40	19.21	26.03*	Pleasant	9.20	15.58	13.06*
16.20	15.25	24.66**	Satisfying	6.80	9.95	9.91**
19.50	33.90	26.03*	Thrilling	10.40	18.61	13.51*
28.10	24.86	24.66*	Embarrassing	43.50	36.36	41.89*
5.70	5.65		Other	10.90	13.85	

Values are reported as a percentage of the whole.

In this question, respondents were asked to compare their first sexual experience to later experiences. The table above denotes the respondents' descriptions of their first experience within the scope of all sexual encounters. “Other” was not included as an option in the 2019 survey.

For both men and women, respondents in 2019 were less likely to describe their first encounter as “scary” and more likely to describe their first encounter as “fulfilling.” Men were increasingly more likely to use

“disappointing,” “pleasant,” “satisfying,” and thrilling” as descriptors of their first encounter. Women were more likely to report an “exciting” first experience than in previous years.

Statistically significant differences between men and women in the 2019 survey include: men being more likely to describe their first encounter as “exciting,” “pleasant,” “satisfying,” or “thrilling”; and women being more likely to describe their first encounter as “embarrassing” or “scary.” The aforementioned descriptors were the largest gaps in responses between genders.

How did religiosity affect responses?		
	Low Religiosity	High Religiosity
Exciting	18.12*	29.56*
Scary	42.75	44.65
Fulfilling	7.97	14.47
Disappointing	54.35	39.62
Pleasant	13.77	18.24
Satisfying	12.32	13.84
Thrilling	13.04	20.13
Embarrassing	38.41	37.11

Values are reported as a percentage of the whole.

Low and high religiosity individuals expressed differing reflections of their first sexual experiences. High religiosity individuals were more likely to report an “exciting” first experience.

Compare the quality of your first experience with later experiences. (Check all that apply). Later experiences were more:						
Men’s responses			Response	Women’s responses		
1988	2009	2019		1988	2009	2019
60.00	59.89	69.86	Exciting	68.90	64.50	65.47
3.80	3.95	1.37***	Scary	3.80	1.73	3.59***
66.60	67.23	61.64	Fulfilling	73.60	63.63	70.40
8.60	6.78	9.59*	Disappointing	7.40	6.93	14.80*
55.20	58.76	64.38	Pleasant	65.90	63.20	65.02
64.30	58.76	67.12	Satisfying	68.30	58.87	74.89
45.70	44.07	47.95	Thrilling	46.20	45.45	47.98
3.80	4.52	2.74	Embarrassing	5.60	3.90	7.62
9.00	7.34		Other	5.60	9.09	

Values are reported as a percentage of the whole.

In contrast to reflections on first sexual experiences, men and women are fairly similar in their assessments of later experiences. Females were more likely to report positive attributes such as “exciting,” “fulfilling,” “pleasant,” and “satisfying” for later experiences than the first experience. They were also less likely to report negative attributes like “scary,” “disappointing,” or “embarrassing.” For men, the responses did not vary much between assessment of first and later experiences. Men followed the same general trend as the women, but with less contrast between experiences.

How did religiosity affect responses?		
	Low Religiosity	High Religiosity
Exciting	70.50	61.64
Scary	5.04	2.52
Fulfilling	70.50	64.78
Disappointing	10.07**	16.98**
Pleasant	71.22*	60.38*
Satisfying	76.98	68.55
Thrilling	49.64	45.28
Embarrassing	7.19	5.66

Values are reported as a percentage of the whole.

Low and high religiosity individuals varied slightly in assessments of later experiences. Low religiosity individuals were more likely to report having pleasant later experiences than high religiosity individuals. High religiosity respondents were likely to be disappointed with later experiences in comparison with their first experience.

If you had to do it over, would you change the experience?						
Men’s responses			Response	Women’s responses		
1988	2009	2019		1988	2009	2019
40.50	38.98	41.24*	Yes	59.50	49.35	56.58*
57.10	58.76	58.76	No	38.50	50.65	43.42

Values are reported as a percentage of the whole.

No significant differences were observed from 1988 to 2019. Since 1988, women of each cohort have been significantly more likely to desire to change their first sexual experience. This could harken back to the differing definitions men and women tend to express for virginity. While women are socialized to see their virginity as a gift, men are socialized to see theirs as a stigma (Carpenter 2002). Thus, it is unsurprising that

women place more value on their first experience and would likely be dissatisfied enough to desire to change it.

If yes, how?

Respondents used a text box to freely express how they would change their first experience given the opportunity. The largest trend in responses was wishing for a different partner (33.51%). These responses were closely coupled with a desire to wait until older, with a broad overlap between the two categories. Desiring a different partner and to wait until older (26.06%) constituted the greatest number of concerns about the respondent's first sexual encounter. When this question was asked in 1988 and 2009, the researchers noticed a sizable number of respondents who wished they had waited until marriage. This desire to wait for marriage specifically seems to have been replaced with a more general desire to have waited. Only six respondents (3.19%) expressed a desire to wait until marriage in 2019. The desire to postpone sexual debut for a later date appears in responses such as "I would have waited longer, had a deeper understanding of the relationship" or "I was too young. I wish I would have waited."

A noteworthy percentage of respondents (20.74%) expressed concerns about consent in their first experience. Some had clearly labeled their own experience as rape or sexual violence. Most others were not as clear in their responses. Some of these responses are likely indicative of sexual violence but could also be expressing a general sense of remorse after the fact. For example, one participant simply wrote, "Would have said no." Whether they had wished to say no during the encounter or had decided afterward is unclear. Confusion over consent is not surprising given that many who perpetrate or experience sexual violence are unsure of whether it was sexual violence (Lonsway and Archambault 2007; Hermann et al. 2012). Coercion can hide under the guise of consensual sex, so it is not often seen as sexual violence. One respondent exemplifies this uncertainty by reporting, "I thought it was completely consensual until I started counseling and realized that it wasn't. Emotionally I was very pressured into it." Many other respondents reported feeling "coerced" or "pressured" without explicitly revealing the lack of consent on their end. These responses exemplify the dangers of living in a culture that does not promote consent-seeking. Many of the respondents expressing concerns over communicating consent likely experienced or perpetrated sexual violence without being aware of it.

Another trend that sets these responses apart from earlier surveys is the sheer number of problems respondents had with their first encounter. Each individual response averaged 2–3 separate types of concerns

over the encounter. For instance, when one respondent says, “I wish that I would have waited longer, used protection and talked about it before it happened,” they concisely express a desire for waiting a longer period of time, using contraception, and communicating with their partner. A common combination of concerns was waiting for a different partner, and older age, as exemplified by the below response:

I think that I would have liked to have my first experience with someone that I felt actually cared about me as a person, not just wanted sex. It definitely would have been a different person and I would have waited until I was a little older.

LIMITATIONS

No empirical investigation of social phenomena is free from limitations. In the first section of this study, we compared results to the 1988 Intermountain West and 2009 SLCC students. Since the first set of data was collected at a number of colleges across the Intermountain West, the responses were not controlled for both time and place. While the study is not longitudinal or a direct replication by any means, it still offers valuable comparisons in regional studies.

It should also be noted that the samples collected in each cohort are not generalizable to the population as a whole since they were collected at a select few colleges with a relatively small sample size. As mentioned in the methods section, the researchers did not have access to the sample size or entire datasets collected in 1988 and 2009. Since that is the case, statistical significance over time could not be calculated. With these statistical limitations in mind, the results should be interpreted with caution. Further research with a probability sample should be conducted before drawing any conclusive results.

In addition, students were asked to define sexual intercourse before reflecting on their first sexual experience by selecting which acts qualify as “sexual intercourse.” The intention behind allowing respondents to use their own definition of sexual intercourse was to avoid the heteronormative assumption that sex is limited to penis-in-vagina penetration. However, upon further reflection, asking the question *before* any questions about their first sexual experience could have primed the respondents to answer differently than they would have otherwise. In retrospect, the researchers should have changed the order of questions to avoid this phenomenon.

DISCUSSION

Collectively, researchers found multiple variations in responses over time and between men and women. Though we do not have access to the dataset of responses from 1988 and 2009 and therefore could not test for statistical significance over time, a few noticeable trends arose. These include but are not limited to inclination toward longer lasting relationships, positive descriptions of first sexual experience, and more complex expressions of affect for each group of gender and religiosity variants. Much like in previous studies, gender acted as a major predictor of quality of first sexual experience.

Numerous trends in responses were observed between 1988, 2009, and 2019. While the mean age of sexual debut stayed static for men, it decreased slightly for women. In 2019, both men and women described their relationship at the time of the encounter as long-term and exclusive at a higher rate. This change is also reflected in their behaviors, as each gender reported knowing their partner for one year or longer before engaging in sexual intercourse with increasing frequency. Both women and men reported entering their first experience willingly more often than in previous years. A paradoxical trend arose in both men and women's affect after sexual debut. While each group selected positive attributes at a higher rate, they also selected some negative attributes more frequently. This seems to reflect a higher degree of fluidity and range of emotions for 2019 respondents. While men were continuously more likely to use birth control from 1988 to 2019, women's use of birth control increased from 1988 to 2009 and then decreased by over 10% in 2019. Each group of respondents reported that both males and females share responsibility of providing birth control. Although respondents changed over time in their reflections on sexual debut, assessments of later experiences remained relatively static.

The split in responses between men and women expressed in earlier studies endured in 2019. Women continued to have more negative associations with their first experience of sexual intercourse, felt less enthusiasm entering the experience, and reported less control over the encounter. The tendency for women to feel more negatively about their first experience surfaced in their reflection of their feelings afterward, and in comparisons to later experiences. Women were significantly less likely than men to report feeling positive emotions afterward (e.g., joy, excitement, gratification, satisfaction) and significantly more likely to use negative descriptors (e.g., fear, guilt, remorse, shame). Women also reported entering the experience eagerly at a lower rate than men, coupled with a higher frequency in entering the experience against their will, with misgivings, or fearfully. Women's responses reflect a lack of

agency in the experience. As mentioned, women were eight times more likely to enter the experience against their will. They were also significantly more likely to report being emotionally or physically pressured into their first experience. Although the reflections are increasingly more positive than in previous studies, the gap in quality of experience between men and women persists.

The researchers had originally sought out to code by genders outside of the male–female binary. However, not enough participants identified as nonbinary or agender to yield any statistically significant observations. Regardless of statistical outcome, adapting questions to include options for genders outside the binary still provides more accurate, meaningful demographic information. By opening the door for including nontraditional genders in future statistical analyses, researchers can better track trends in gender identification over time.

One major objective of the study was to measure religiosity as a predictor of sexual experience and attitudes. While researchers observed statistically significant differences in responses between low and high religiosity individuals, these differences were not quite as abundant as with gender. Low religiosity individuals had their first experience of sexual intercourse one year earlier than their high religiosity counterparts, on average. Those with high religiosity reported experiencing sexual debut in a married relationship over three times as frequently as low religiosity individuals. High religiosity respondents were also more likely to report feeling guilt after their first sexual experience.

Perhaps the most noteworthy divide in low and high religiosity responses was observed in their comparisons of first and later experiences. High religiosity individuals were more likely to remember their first experiences as exciting, while low religiosity respondents were more likely to describe it as disappointing. The answers shift slightly in later experiences, however, as low religiosity individuals are more likely to describe the experiences as pleasant.

Future research in this area should take an intersectional approach to how different groups of respondents feel and behave sexually. While this study looked at gender and religiosity as individual predictors of sexual affect and attitudes, a more meaningful analysis may consider the combined impact of gender and religiosity by examining highly religious women specifically. Other studies examining sexual debut in the ADD Health Survey have found that religiosity more strongly influences the timing of women's sexual debut than men's (Higgins et al. 2010). With this in mind, it is of interest whether high religiosity influences women's perceptions and behaviors surrounding sex in more depth. Examining responses to this survey through an intersectional lens by using interactive

statistics could have more explanatory power than examining gender and religiosity individually.

ACKNOWLEDGMENTS

First and foremost, we thank the students who participated in the survey. We would also like to express appreciation for faculty members who distributed the survey and made suggestions and observations as we collected the data. Special thanks goes to Dr. Jessie Winitzky-Stephens and VP Jeff Aird, who granted us access to Qualtrics and offered institutional support throughout the research process. We also express gratitude to Daniel Poole for easing the process of IRB approval.

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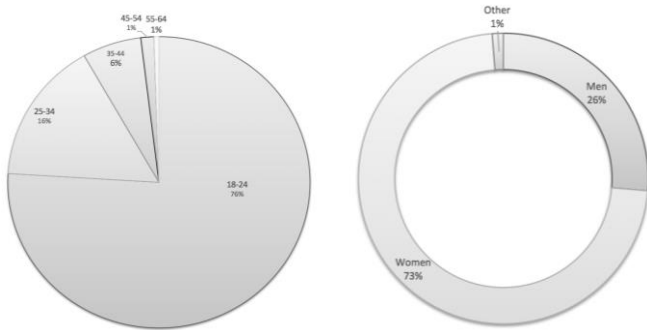
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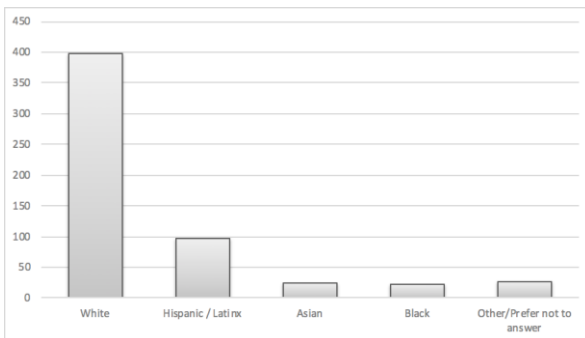
APPENDIX A: DEMOGRAPHICS

Age and Gender Identity



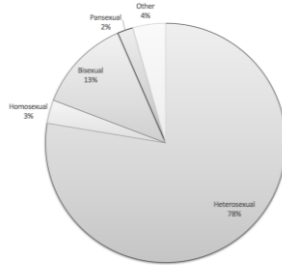
Race/Ethnicity

Because of the wide breadth of racial/ethnic identities displayed in SLCC students, a large number of categories were grouped as “other.” See raw data for specific categorical breakdowns.



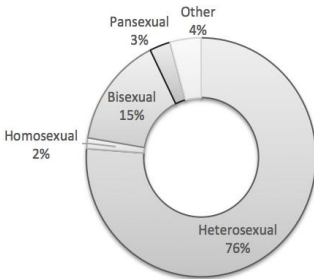
Sexual Orientation

Researchers observed a sizable minority of bisexual respondents. Approximately 13% of the students surveyed were bisexual, compared with the national average reported in 2016 of 5.5% for women age 18–24 (Copen et al., 2016). This change could be attributed to a growing number of bisexuals or to the fact that the sample for this study is exclusively college students.

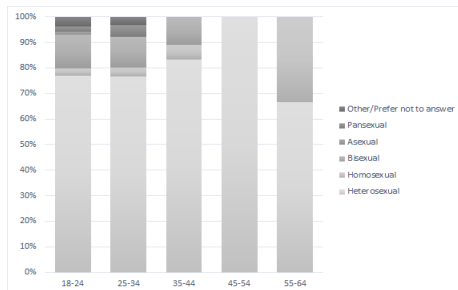
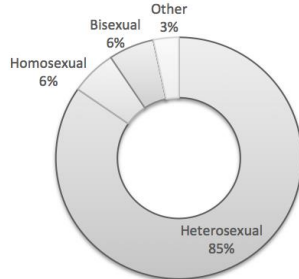


Sexual Orientation by Gender and Age

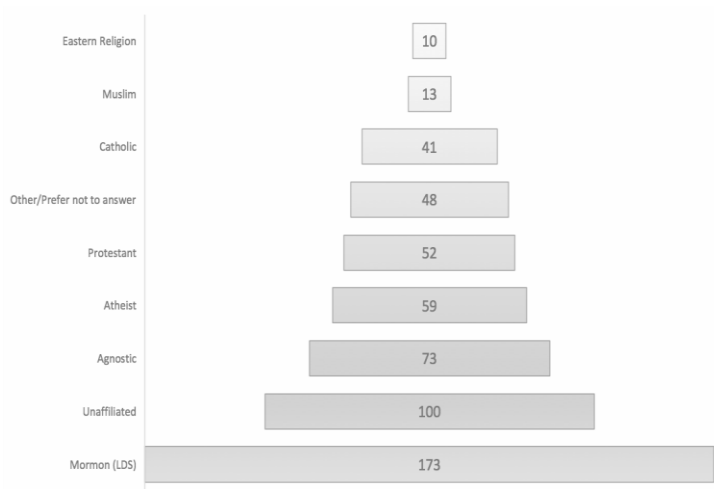
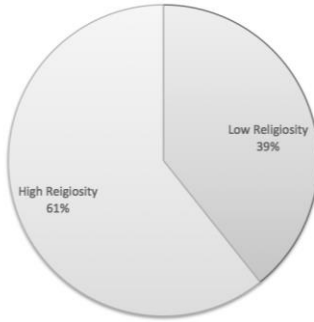
Women



Men



Religiosity and Religious Group



Abstracts

ARTS

Rethinking the Ecology of Islamic Geometric Ornament

Barry Wood

Dixie State University

Geometric ornament in Islamic art is often interpreted in a framework of alleged mystical symbolism. This paper is part of an ongoing project to rethink Islamic ornament and how we relate to it as this-worldly human beings. Building on recent thinking in psychology and neuroscience, I argue that the aesthetic appeal of geometric pattern comes from the sense of cognitive efficacy it affords. Recognizing a pattern means grasping that certain shapes will repeat at certain intervals. A geometric pattern thus provides a field of perceptual input in which the successful prediction of how the world is going to behave (at least in this context) is simple, almost effortless, and the feeling of having succeeded in its fundamental task is uniquely rewarding to human consciousness. The contrast with the difficulty of discerning pattern in the world of things and people, in turn, suggests an explanation for the appeal of geometric ornament to commentators attracted to supernaturalist metaphysics. To illustrate my analysis, I will draw on examples of geometric ornament from around the Islamic world, including patterns from architecture, manuscript illumination, and carpets.

ARTS

The Florentine Codex and the Mexica Revival

Travis Lee Clark

Utah Valley University

In the wake of the Conquest of Mexico, the indigenous population suffered brutal repression under the *encomienda* system. Natives were required to provide forced labor to the conquerors. The old temples and cities were obliterated and native customs, including native art forms,

were suppressed. When the New Laws were passed in 1542, they not only liberated much of the native population, they also, remarkably, recognized the titles and land rights of native nobility. This created an interest not only in native genealogy but in native culture as well. Pre-Columbian themes and motifs that had once been banned began to proliferate. However, the previous suppression of native art forms, and subsequently native artists as well, had impoverished the indigenous artistic vocabulary. When regarding this Mexica Revival, considerable questions remain about what constitutes a survival of the pre-conquest past, or what represents a revival, an innovation created from a pastiche of pre-conquest forms mixed with imported Iberian forms. Separating the Old World from the new has been a daunting challenge, but the incredible 10-volume ethnographic study by the Franciscan Friar Bernardino de Sahagún known as the Florentine Codex, gives us a means of examining this problem in detail. With over 3000 unique illustrations by native artists, the text provides an excellent opportunity to explore the question of how much continuity the artists of the late 16th C. maintained from their pre-conquest heritage, and how much they chose or were forced to adapt to the new culture because the old one was lost. By comparing these illustrations to existing Pre-Columbian examples and Iberian sources, we can hope to narrow down the question of whether this represents a survival or a revival of artistic tradition.

ARTS

The Aftershocks: A Research through Dance on the Emotional Symptoms of Persistent Complex Bereavement Disorder

Francesca DeMartino

Utah Valley University

According to the DSM- 5 (Diagnostic and Statistical Manual of Mental Disorders Fifth Edition), Persistent Complex Bereavement Disorder (PCBD) affects approximately '2.4%–4.8%' of the populus with unimproving, sustained grief. This disorder is classified one year after the loss of a close relationship due to death causing intense mixed emotions, a desire to be reunited with the deceased, and other symptoms that cause significant distress. As a choreographer who creates work on psychological topics, I sought to connect the two worlds and investigate the emotional properties of the PCBD. In this research project, I explored several PCBD criteria through dance by working with the properties of

Time, Space, and Energy. The emotional criteria explored are: (1) intense sorrow/emotional pain, (2) disbelief/emotional numbness, (3) anger/bitterness, (4) confusion about one's role in life or a diminished sense of identity, and (5) feeling alone/ detached from other individuals. In this piece, each dancer represented the physical manifestation of one criteria. Thus, I was able to explore each emotion individually and how the emotions interact with each other and as a whole. Each dancer worked with a different tempo correlating to their emotion (i.e., sorrow is slow, confusion is fast, etc.), and I explored how their tempos changed when interacting with another emotion. I played with spatial patterns and stage placement to show the conflict between different emotions, the ability for one emotion to overpower another, and the cooperation between all the distinctly separate emotions. With Energy, each of the different criteria had a unique movement quality reflecting the emotion (i.e., sorrow is sustained, anger is percussive, etc.). It is my intention for this research to translate the clinical emotional criteria of PCBD into a physical experience that will help the audience understand and become aware of this disorder.

ARTS

Japanese Ideals Found in Michio Ito's Choreography and Technique

Meladi Hodges

Utah Valley University

Cultures create different values and ideals that help them make sense of the world. They are implemented throughout various products of society. New Historicism is a postmodern frame of analysis that connects any work to its original time and place of creation, thus providing insight into the culture through what they value. Dance is a product of culture, and by studying its essential aspects, it is clear that dance reflects culture. This research will show, through a New Historicism perspective, that Michio Ito's choreographic philosophies for his works Scriabin Prelude #V and Scriabin Preludes #VI are reflective of Japanese cultural ideals. The Japanese culture views the world through their created values and ideals. These are vital in their society, as they are seen in every aspect of their lives. These ideals include Makoto, Yugen, Iki, and In-Yo. They were created to shape the understanding and beliefs of citizens of Japan. A major theme in these ideals is complimentary opposites working together to make a whole. Another theme is a sense of loyalty: never

straying from one's true self. Understanding these ideals will create a deeper understanding of dance in Japan. Michio Ito was born in Japan in 1892 and immigrated to the United States to create his own modern choreography. His technique, "Ten Gestures," was the basis of his creations such as Scriabin Preludes. These works showcase many Japanese cultural values that Ito was influenced by. This research was drawn from reviewed source materials—written and recorded—videos of Repertory Dance Theater (RDT) performing Ito's work, an interview with Sarah Donohue, a former RDT member, and a critical analysis of Scriabin Preludes #V and #VI employing Laban Movement Analysis (LMA). LMA is a neutral system of analyzing movement, developed by Rudolf Laban, through the elements of body, effort, shape, and space.

ARTS

"Triangle of the Squinches" Through A Feminist Perspective

Mattea Rogers

Utah Valley University

The social world of ballet depends on a uniformity of body shape and size, which is predicated on physical architecture as the balletic body emphasizes preciseness in line, placement, and visual design. This corporeal perfection is usually defined as bodily practices and the slender ideal (Pickard 7). Because feminist criticism seeks to examine the oppression of women (Tyson 83) and oppression is defined as a type of injustice by the inequitable use of authority, law, or physical force to prevent others from being free or equal (Napikoski 1), the feminist perspective is the frame of analysis that will be used to describe the stereotype of female ballet dancers. By looking through the feminist perspective at the stereotype of female dancers, specifically in the 'Triangle of the Squinches' by Alonzo King LINES ballet, a clear understanding of how female dancers are stereotyped in the 21st century world of ballet will become clear. In this paper the feminist perspective will be discussed as a way to examine the oppression of women (Tyson 83), female ballet stereotypes will be defined and explored as petite, elegant and weightless (Pickard 16), and an analysis of 'Triangle of the Squinches' through a feminist perspective will be informative of the female body in dance. Sources of the research will include a critical analysis of 'Triangle of the Squinches' (a video source), a review of written sources, and an embodied experience of the dance. Because all

forms of dance reflect the cultural traditions from which they developed (Kealiinohomoku 33), a discussion and analysis of ‘Triangle of the Squinches’ will reveal the cultural beliefs and traditions in which it was performed. As the feminist perspective, ballet stereotypes, and ‘Triangle of the Squinches’ are explored, the representation of 21st century women in the world of ballet will be revealed.

ARTS

Wigman's Hexentanz

Vicky Clark

Utah Valley University

The late nineteenth and early twentieth centuries marked a dramatic period of change throughout the World, especially in Germany. (Fensham 2011, Karina 2004, Newhall 2009) Political events surrounding World War I, artistic movements that focused on fracturing the past in an effort to innovate for the future, and dramatic social changes marked the turbulence of the Post Romantic Era. Amidst the chaos, Mary Wigman emerged as a student of Modern Dance and created her piece Hexentanz. While several researchers (Kirina 2004, Partsch-Bergsohn 2003, Reynolds 2003) have looked at this work and its relationship to historical and political events, a new evaluation placing deeper consideration on the artistic milieu of the times, as well as Wigman’s personal experiences with the artistic environment in which she lived, will reveal new knowledge about the effects of those influences and how they are revealed in the movement vocabulary within the dance. Focusing on Wigman’s performance of Witch Dance II, in 1926, and gazing through the lens of New Historicism, such artistic movements as Ausdruckstanz, Expressionism, and Dadaism will be examined. Deeper connections will be made through review of the activities of specific artists that Wigman acknowledged as influential in her work such as Emile Nolde and teacher/dancer Rudolf von Laban. Additionally, review of existing film footage of the actual performance by Wigman herself, along with a conversation with Sarah Donahue who learned and performed the same version of Hexentanz as a part of the Alumni Concert at the University of Utah in 2007, will provide important insights to the elements of Body, Energy, Shape and Space. Written source materials will allow deeper assimilation of all facets of this artistic event, clearly demonstrating that once again, dance does, in fact, reflect the culture in which it is created (Kealiinohomoku 2001).

ARTS

Zion's Call: Embodied Belief in Virginia Tanner's Woman, the Pioneer

Pat Debenham, Kathy Debenham

Utah Valley University

This paper will examine the creation, performance, and re-creation of Virginia Tanner's heroic work *Woman, the Pioneer*. Following a brief introduction that highlights Tanner's history and addresses her influence regionally and nationally, the presentation will address how, historically and culturally, the dance captures the physical and metaphoric experience of the Mormon migration. The presentation will highlight how the work embodies the faith, hope and beliefs of women who crossed a continent with little more than family and the clothes on their backs and explore how, through stylized movement, the dance addresses themes of migration, displacement, loss, gathering and community. Through the lens of Laban Movement Analysis, it will show how embodiment of thematic material from the five main sections of the work reveals the arc of struggle and challenge to resolution and peace that the Mormon pioneer women experienced.

BIOLOGICAL SCIENCES

Thermal Niches of Fleas from Deer Mice in the Great Basin Desert: Implications for Biodiversity Conservation

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Seasonality of fleas on North American deer mice (*Peromyscus maniculatus*) varies. During several years, 25 flea species were found on deer mice in the Great Basin Desert, with the dominant flea being *Aetheca wagneri*, which occurred throughout the year and comprised 46% of all fleas collected. I fitted nonlinear curves to estimate realized thermal niches. *A. wagneri* is tolerant of the extreme climate (0°C to 22°C, 33°F to 71°F) typical of western North America. At colder temperatures, *A. thamba* replaces *A. wagneri*. In contrast, secondary fleas on deer mice show narrow thermal niches that appear partitioned to minimize overlap, as has been observed for fleas on other mammals such as flying squirrels. Although deer mice are endotherms, the off-host portion of a flea's life cycle is greatly affected by the abiotic

environment. Phylogenetic constraints may limit secondary fleas, but the role of flea competition and dispersal in causing thermal niche displacement requires further research. In general, climate change will alter the flea community of deer mice and its disease cycles; the Centers for Disease Control estimates that bites on humans from fleas and other major arthropod vectors have tripled since 2004. In regard to overall biodiversity, when climate change causes thermal niche displacement (genetic change) and shifts (migration) that minimize thermal niche overlap, outbreaks of species, but endangerment of other species, will occur. "No analog" communities will develop, and many ecosystems may revert to diminished, earlier succession functioning. Thermal niche complicates biodiversity conservation.

BIOLOGICAL SCIENCES

Analysis of Four Plant Organellar tRNA Genes: More Evidence of Gene Transfer

William D. Speer

Salt Lake Community College

Horizontal gene transfer (HGT) has been documented by previous researchers between chlamydial genomes, on one hand, and plant mitochondrial and/or chloroplast genomes, on the other. This study attempts to further evaluate potential HGT between these genomes by phylogenetic analysis of four tRNA sequences (trnD-GUC, trnN-GUU, trnQ-UUG, trnS-GCU) already deposited in GenBank. In addition, corresponding tRNAs from cyanobacterial and γ -proteobacterial representatives were also assessed. For trnN-GUU and trnS-GCU, both previously evaluated and additional new sequences were included in this study. The results obtained here are consistent with the earlier hypothesis of HGT from chlamydia bacteria to certain plant mitochondrial genomes for these two genes. Additionally, new examples of possible HGT are presented here for trnN-GUU, which include one chloroplast copy for *Dryopteris blanfordii*, 2) a mitochondrial copy for *Psilotum nudum*, and 3) a putative mitochondrial pseudogene for *Ginkgo biloba*. Although not showing chlamydial associations, the multiple copies of trnS-GCU in the highly complex and diverse mitochondrial genome of the basal angiosperm *Amborella trichopoda* were placed in one of two differing relationship groups for 1) angiosperms and 2) green/red algae. While most copies of mitochondrial trnD-GUC genes for *Amborella* grouped with the mitochondrial copies of diverse taxa, including angiosperms,

mosses, and lycophytes, other copies had definite chloroplast relationships, suggesting possible promiscuous gene transferal between the chloroplast and the mitochondrion. Similar observations for the various *Amborella* trnQ-UUG copies were also made with respect to mitochondrial and chloroplast relationships. Altogether, these results indicate that relationships for some plant organellar genes may not necessarily follow endosymbiotic expectations.

BIOLOGICAL SCIENCES

Distribution and Microbial Use of Molybdenum in Soils West of Milford, Utah

Matt Harmon, Huh JungYun, Elizabeth Pierce, Kim Weaver
Southern Utah University

Our study looks at molybdenum concentrations in soil and how molybdenum is being used by soil microbes and plants. Molybdenum is an essential component of nitrogenase, a nitrogen-fixing protein found soil bacteria, as well as in other proteins important for sulfur and nitrogen cycles and for chemical reactions of small metabolites. In environments rich in organic matter, molybdenum is bound and retained by compounds made by plants, bacteria, and fungi. Our study site, just northwest of Milford, Utah, is in the area of outflow from a tungsten mine. Initial surveys found variable molybdenum concentrations over an area of about six square miles, with at least one small spot of much higher concentration rising and falling over about 0.2 miles. The ecology of our study site is much different than areas previously tested in that the main plants are widely spaced sagebrush and occasional clumps of grasses. In some areas, the soil surface is covered with black cryptobiotic crust. In our previous work, we surveyed metal concentrations relative to sage bushes. Our current proposal includes comparisons of cryptobiotic crust with the underlying soil and amplicon sequencing to identify organisms in the cryptobiotic crust.

BIOLOGICAL SCIENCES

Supporting Lipid Bilayer Removal by Buffer Flow

Ruth Hunter, Micheal Ornstead, Christopher Monson

Southern Utah University

The investigation of proteins in the bilayer is difficult to do, because of the complexity of the bilayer. To access the proteins in the bilayer could be very beneficial to furthering our understanding of the functions of proteins we have never had access to. Each protein has specific functions, and there are processes to determine what their functions are when they are in the individual proteins, but it is not known how to separate the proteins of the bilayer into their individual protein structures. To be able to separate the proteins in the lipid bilayers and determine their functions could eventually lead depositing functional proteins to malfunctioning proteins of similar functions. Our project focuses on using a microfluidic device approach to strip individual vesicles in the lipid bilayer. Since the beginning of our project, we have been successful in using the microfluidic device in separating vesicles using lipid bilayers. There is still some work to be done as we are working on confirming that we are stripping the bilayer, through reformation of the bilayer. There have been some successful runs of reformation; we are now working on obtaining a larger range of data.

BIOLOGICAL SCIENCES

The Effects of Housing and Feed on Nutritional Content of Eggs

Zack Hansen, Lindsey Roper, Elizabeth Pierce

Southern Utah University

Across the United States, the terms "locally grown" and "sustainable farming" have grown in popularity over the last ten years. This has led to an increase in the popularity of farmers markets, home gardens, and small backyard chicken coops for fresh eggs. While there is consensus that the nutritional content of vegetables increases when grown in small-scale farms and reduced time between harvest and consumption, there is less known about how small-scale production of eggs affects nutritional content. Research has been performed for large-scale operations, and it has been shown that numerous nutritional benefits can be gained when hens have access to pasture. The purpose of this experiment is to

determine the nutritional differences among chicken eggs from hens eating varied diets, including differences between hens with and without access to pasture in small home-farming environments. The experiment is specifically designed to mimic methods for raising small-scale, backyard chicken flocks. The nutritional content of these eggs will be compared with store brand, mass-produced eggs as well as store-bought organic eggs. Although not a central focus of the experiment, additional data will be gathered for efficiency of production, cost of feed, and amount of food waste avoided (by implementing appropriate food scraps as a part of some diets). Comparisons will be made among two different flocks with different diets as well as store-bought eggs and USDA data. We believe that our small-scale operation will show what could be considered nutritional benefits (in terms of their eggs) for hens with access to pasture and/or food scraps as compared with those without access, providing comprehensive evidence that backyard chicken-raising operations provide more nutritious eggs.

BIOLOGICAL SCIENCES

Identifying Factors Contributing to Spatial Patterns of Mule Deer-Vehicle Collisions

Michael Christiansen, Darby Adams, Natalie Barlow, Karl Jarvis
Southern Utah University

Habitat fragmentation caused by Utah road systems contributes to wildlife-vehicle collisions (WVCs) with Rocky Mountain mule deer (*Odocoileus hemionus hemionus*), costing millions each year in damage, death, and injury to humans and animals. Our research focuses on identification of ecological and physical factors driving WVC density with the goal of suggesting road mitigation measures that could be implemented by the state. Our hypotheses were that vegetation, topographic roughness, and status of fences along roadways affect WVC density and distribution. Our team gathered data on fence status along the highway, as well as vegetation density extending out from the road using GPS. We also calculated summary statistics of topographic roughness and vegetation using remotely sensed elevation and landcover data. We used this data to build models to predict the density of WVC incidents along Highway 56 in southern Utah, as measured by the Utah Department of Transportation. We supplemented this with photographic and video data captured from wildlife cameras around significant WVC hotspots and a GPS dash camera. We imported our data into the R

environment to compile and model our data via multiple regression and model selection to identify factors that best predict WVC density on Highway 56. We found that, of the variables we tested, fencing and topographic roughness were the most important predictors of the presence of WVC hotspots. Our top models also contained vegetation density at 15–20 m, but generally not less than 15 m, and we found that general vegetation cover density was a poor predictor of WVCs. This work will allow us to make recommendations to road planners on the locations of potential mitigation structures, such as appropriately sized culverts or revised fencing, which could significantly reduce risk to drivers and wildlife.

BIOLOGICAL SCIENCES

Effect of Initial *Lactobacillus wasatchensis* WDC04 Inoculum Levels and Ribose

Ireland Green, Craig Oberg, Donald McMahon

Utah State University and Weber State University

Lactobacillus wasatchensis WDC04 is an obligatory heterofermentative non-starter lactic acid bacteria that causes late gas defect in Cheddar cheese by cleaving a carbon off galactose (resulting in CO₂) when its preferential carbohydrate source, ribose, has run out. Initially, WDC04 growth was examined at a pH of 6.5, 5.2 (cheese pH), and 5.2 with 3% NaCl. Growth curves were determined using MRS-carbohydrate restricted (MRS-CR) broth with 1% ribose adjusted to each pH. Growth was slowest for WDC04 at pH 5.2 + 3% NaCl, then pH 5.2, followed by pH 6.5. It was subsequently investigated if ribose restriction and increased galactose would result in greater CO₂ production. The following ratios of ribose:galactose were used; 10:90, 20:80, 30:70, 40:60, and 50:50 for a total of 1% carbohydrate in MRS-CR broth (pH 6.5). Each ratio was inoculated with WDC04 from 10¹-10⁷ CFU/ml, with each dilution done in triplicate in tubes containing Durham tubes for gas detection. Gas production was observed between 8 and 15 d when incubated at 23°C. Gas production was 66% or higher for 10⁵-10⁷ inoculated 20:80 tubes, 10²-10⁷ inoculated 30:70 tubes, 10¹-10⁷ inoculated 40:60 tubes, and 10³-10⁷ inoculated 50:50 tubes. Gas production was 33% for the 20:80 ratio dilutions of 10³ and 10⁴ and for 50:50 ratio when inoculated at 10² CFU/ml. For some dilutions, two tubes showed gas production and for others, only one tube had gas reflecting the variability seen in commercial cheese ripening. Ribose was

required at a threshold level of 0.3% for gas formation at most inoculum levels when galactose was present. At higher inoculum levels (105-107 CFU/ml) only 0.2% ribose was sufficient. As ribose concentration increased, the initial inoculum for gas production decreased, showing a correlation between WDC04 cell growth due to ribose availability and eventual conversion of galactose to gas.

BIOLOGICAL SCIENCES

Analyzing Attitudes toward the Use of Essential Oils among UVU Students

Hunter Brittain, Nathan Fletcher, McKay Echols, Zachary Medved, Olga Kopp

Utah Valley University

Essential oils are immensely popular in the state of Utah. Proponents of essential oils suggest that they can be used to improve an array of emotional and physical ailments. Whether they are an effective, helpful, home remedy or not, the perceptions on the therapeutic efficacy of essential oils vary greatly. However, research on the perceptions of essential oils among college-educated adults in the state of Utah is lacking. Receiving higher education in the sciences may influence skepticism of essential oils as a complementary and alternative medicine. The purpose of this study is to understand how Utah Valley University students' education influences their attitudes towards essential oils as complementary and alternative medicines. The information gathered about the students' views on essential oils will be compared with their respective educational disciplines and gender.

BIOLOGICAL SCIENCES

Actinomyces and Pigment Production

Bailey Meibos, Alexis Thomas, Michele Culumber

Weber State University

Actinomyces are gram-positive bacteria that grow as rods or filaments and are commonly found in soil. The actinomyces bacteria have a very large genome containing roughly 2,900,000 base pairs; this large genome allows the bacteria to code for a large variety of proteins. Actinomyces

are known for their pigment production and their ability to produce antibiotic compounds. Nearly two-thirds of natural antibiotics currently used clinically are derived from actinomyces. Two actinomyces were isolated from soil samples and were grown on Nutrient Agar, One-Tenth Nutrient Agar, and Arginine Glycerol Salt Agar in aerobic conditions. The two isolates produced pigments of various colors and shades (pink, purple, and blue) depending on the medium. Our objective is to identify the isolates as well as determine how the environmental conditions effect the production of pigment. The isolates will be grown in broth and the 16S rRNA from each isolate will be sequenced to identify the organisms. The pigments will also be examined to determine if environmental or nutrient conditions influence the production of pigment. Nutrient composition of each media will be studied to determine if pigment production is dependent on a single nutrient that differs between the various media. Previous research states that nutrient composition and pH have an effect on pigment production. Previous research also states that pH has a larger effect on pigment compared with nutrients present in the agar; however, all three of the media types used thus far have a neutral pH (pH of roughly 7). Based on the preliminary results, it is reasonable to conclude that pH is not a significant factor of pigment production for the two organisms present. Better understanding of how culture conditions influence pigment production may provide valuable insight about the requirements for these organisms to produce other complex molecules, including antibiotics.

BIOLOGICAL SCIENCES

Anti-fungal Synergistic Effect of Amphotericin B and Posacanazole with Thymol and Cinnamaldehyde against *Rhizopus oryzae* Biofilm

**Jedediah Orullian, Tyson Hillock, Levi Neely, Blake Johnson,
Ashley Balderrama, Iryna Chelepis**
Utah Valley University

Mucormycosis is a fungal infection primarily caused by *Rhizopus oryzae* and associated with biofilm growth. Biofilms increase resistance to antimicrobial agents and enhance the growth of the microorganisms. In this study, synergistic treatment of the common antifungal agents amphotericin b (amp b) and posacanazole will be used in conjunction with major phytoconstituents of the thyme and cinnamon—thymol and cinnamaldehyde, respectively. This research will investigate the

antifungal effects of these treatments against *Rhizopus oryzae* biofilm. An optimal concentration of the antifungal agent and paired phytoconstituent will be determined. Studying fungal behavior in the biofilm can provide more accurate information about the treatment response, since biofilms are similar to the environment found in human bodies. Amp b is the primary treatment of the majority of fungal infections, but it has various toxic side effects, such as hepatotoxicity and nephrotoxicity. Even at low concentrations, common side effects of amp b are nausea, muscle or joint pain, and headaches. High concentrations of amp b are needed to treat mucormycosis. *Rhizopus oryzae* biofilms will be grown in 96-well plates. A triplicate of synergism plates will be treated with a gradient of dilutions from amp b and posacanazole and a gradient of dilutions of the phytochemical. The biofilms will be washed and treated with XTT/menadione. The amount of inhibition will be determined by absorbance and Crystal Violet Binding Assay. It is expected that a prepared concentration of amp and phytochemical will result in similar inhibition as amp b alone but with less amp concentration.

BIOLOGICAL SCIENCES

***Borrelia burgdorferi* Biofilm: An Investigation into Growth and Control of an Alzheimer's Disease-Associated Bacterium**

Tyson Hillock, Kyle Hendricks, Landon Barlow, Rachel Callister, Micheal Richards, Olga Kopp

Utah Valley University

A strong correlation between the bacterial family Spirochaetaceae and the pathogenicity of Alzheimer's Disease (AD) exists. Spirochetes have an affinity for neural tissue and readily reside on the brain where they grow, not as free-floating planktonic cells, but as biofilms: communities of aggregated cells that provide added resistance to antimicrobial agents. Though microorganisms naturally exist as biofilms, they have primarily been studied in the planktonic state, and the clinical importance of biofilms is often underestimated. The body responds to *Borrelia burgdorferi* biofilms on the brain by recruiting amyloid-beta (AB) in an attempt to neutralize the bacterium. AB is unable to penetrate the biofilm and begins to accumulate on the brain, ultimately initiating degeneration of the neurocircuitry. This study aims to successfully grow *B. burgdorferi* biofilms and investigate the inhibitory properties of

antibiotics in biofilm formation. *B. burgdorferi* will be cultivated over various periods of time, using one of two media: modified BSK-1914 media with 6% rabbit serum, and modified RPMI-1640 media with 6% rabbit serum. The biofilms are exposed by removing the planktonic cells and then are treated with XTT/Menadione assay for cell viability. The most effective time length and media for biofilm growth will be determined. That procedure will then be used to cultivate biofilms that are subject to various antibiotics. Spectrometry of the XTT/Menadione assays will be the primary method used to determine cell viability and the inhibitory effects of antibiotic treatments. Future work into the investigation of combination therapy, a process of using several medications and modalities such as low-level light therapy, low-frequency ultrasound, and extracorporeal shockwave therapy will be pursued. The results of this work could provide expanded knowledge of inhibition of *B. burgdorferi* biofilm growth and one day lead to increased understanding of the pathogenicity and treatment of AD.

BIOLOGICAL SCIENCES

Effect of Extracorporeal Shockwaves on *Rhizopus oryzae* Biofilm

Tyson Hillock, Karaleen Anderson, Katjia Sterflinger, Cyril Slezak, Paul Slezak, Olga Kopp

Utah Valley University

Fungal infections have gained clinical importance in the last decade. These serious and sometimes fatal infections are often associated with biofilm formation, which can increase resistance to antifungal agents when compared to free living colonies. This increased resistance makes it vital to test antifungal susceptibility using biofilms and not planktonic cells. Fungi belonging to the class Zygomycetes, namely *Rhizopus*, *Rhizomucor*, *Absidia*, *Mucor*, and *Lichtheimia* have been implicated in an opportunistic, and sometimes fatal infection known as mucormycosis. Although ubiquitous in the environment, this species can be associated with uncontrolled diabetes, diabetic ketoacidosis, hematological problems, malnutrition, trauma, and burns. Amphotericin B (ampB) has been used as the first line of treatment for mucormycosis since the 1950s. However, it can have many adverse side effects including chills, fever, headaches, and muscle pain as well as the fatal syndromes of hepato- and nephrotoxicity. These side effects, in conjunction with mortality rates of 97% (untreated) and 39% (treated with ampB), demonstrate the need for

alternative treatment options. An intriguing treatment possibility is the shockwaves produced by extracorporeal shockwave therapy (ESWT). A shock wave is described as a high-energy wave characterized by a sudden change in pressure, temperature, and density of the traversing medium. Differing from pressure waves, a shockwave is a single event of energy dissipation with no frequency associated with it. ESWT is currently used in lithotripsy and has shown promising results towards soft tissue regeneration. By combination of shockwaves and antifungal agents, the necessary concentration of ampB could potentially decrease. This study aimed to investigate the potential disruption of fungal biofilms by high- and low-energy shockwaves. Although synergistic effects of ESWT and ampB showed an unexpected increase in biofilm formation rather than the anticipated disruption. Hypotheses towards this phenomenon are under preparation for further investigation.

BIOLOGICAL SCIENCES

Characterization of the Hemolytic Metabolites of Probiotic Lactobacilli

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Weber State University

Probiotic lactobacilli (PLBs) are valued for their supposed health promoting aspects. However, we observed that seven PLBs caused beta hemolysis when grown on sheep blood agar (SBA), a characteristic of pathogens. This study's goal was to characterize this hemolysis. Initially, PLBs were inoculated onto SBA, incubated at 25, 30, and 37°C, aerobically and anaerobically. All seven PLBs lysed SBA after 2–4 days of incubation under all conditions. Five PLBs were grown in broth for 2 and 6 days, filter sterilized to obtain cell-free culture supernatants (CFCSs). These were plated on SBA and incubated for 24 hours. All five CFCSs of the PLBs caused yellow-opaque alterations of the SBA, with day 6 CFCSs causing larger alterations than day 2 CFCSs. The pH of CFCSs was adjusted to pH 6 and non-cultured broth to 3.5. These were tested along with the original CFCSs (pH 3.4–3.5) on SBA. All pH 3.4–3.5 CFCSs caused a yellow-opaque alteration of the SBA, while pH 6 did not. In contrast, non-cultured broth of either pH did not alter the SBA. These data indicate that the yellow alteration of the blood is a metabolite of the lactobacilli and is pH dependent. To test the heat-labile nature of the CFCS metabolites, they were autoclaved and plated on SBA. After

24 hours of incubation at 30°C, the heated CFCSs caused a yellow-opaque alteration of SBA indicating these metabolites were heat stable. Further biochemical characterization of the metabolites included attempts to separate the active component(s) by molecular weight filtration, methanol extraction, and sensitivity to catalase. Our evidence suggested H₂O₂ was one of the yellowing agents. Interestingly, the active CFCS products were never able to cause beta hemolysis similar to that caused by lactobacilli colonies growing on SBA.

BIOLOGICAL SCIENCES

Media Optimization to Differentiate *Lactobacillus* and *Bifidobacterium* species in Fermented Dairy Products

Nicole Smith, Courtney Burns, Craig Oberg

Weber State University

Lactic acid bacteria (LAB) are used to produce a wide variety of fermented dairy products including cheese and yogurt. Many of these products contain added probiotic cultures, primarily species of *Lactobacillus*, *Bifidobacterium*, and *Streptococcus* that can provide health benefits to the consumer. To determine shelf life survivability of probiotic cultures in fermented milk products, it is necessary to differentiate them from the LAB starter cultures used to ferment the product. This research was done to determine the optimal media for differentiating probiotic species based on colony morphology differences and exclusionary growth from the starter LAB. Eight different media were examined for their ability to differentiate among 9 species of *Lactobacillus* and 3 species of *Bifidobacterium*. Results show RCA agar with methylene blue can differentiate between the colony morphology for *Streptococcus thermophilus*, *Lactobacillus fermentum* and *Lactobacillus brevis* strains used in this study. MRS agar with vancomycin, used to enumerate *Lactobacillus casei*, also supported growth of *Lb. fermentum*, *Lb. brevis*, and even *Bifidobacterium animalis* ssp. *lactis*. Skim milk media was performed in three separate trials showing previous results were inclusive. All lactobacilli and bifidobacteria grew on MRS plus sorbitol, normally used to enumerate *Lactobacillus acidophilus*. Skim milk media also failed to differentiate between *Lactobacillus* and *Bifidobacterium* contrary to published results. MRS-NNLP agar, containing cysteine, nalidixic acid, neomycin sulfate, lithium chloride, and paromomycin sulfate, has traditionally been used to select for *Bifidobacterium* by excluding the growth of

Lactobacillus species. However, several *Lactobacillus* species including *Lb. fermentum*, *Lb. brevis*, and *Lb. casei* produced colonies on this media, which limits its value when these LAB species have also been added to the product during manufacture. Results show current plating media are inadequate for differentiating starter LAB from added probiotic cultures to provide an accurate enumeration of the different LAB strains in a fermented milk product.

BIOLOGICAL SCIENCES

Non-starter Lactic Acid Bacteria Growth in Cheddar Cheese

Amanda Varley, Ashley Smith, Michele Culumber, Donald McMahon, Craig Oberg

Weber State University

Non-starter lactic acid bacteria (NSLAB) growth in cheese can impact the quality of the finished product. Evidence suggests that as cheese ages, the number of NSLAB increases while the number of starter lactic acid bacteria (SLAB) decreases. Our objective was to correlate the growth of NSLAB in aging cheese with the detection of *Lactobacillus wasatchensis*, a NSLAB known to cause gas defects. Two batches of Cheddar cheese were made in a facility with *Lb. wasatchensis* contamination and aged for 5–48 weeks. SLAB and NSLAB in the cheese were quantified over a 3-month aging period. At each time point, dilutions of the cheese were plated on MRS agar supplemented with 1% ribose and incubated anaerobically to quantify NSLAB growth. During aging, the SLAB remained at about 10^8 cfu g^{-1} , while NSLAB increased from below detection to 10^8 cfu g^{-1} . DNA was extracted directly from the aging cheese at regular intervals using a modified DNeasy Soil DNA Extraction Kit (Qiagen). DNA yields ranged from 445 ng g^{-1} to 2.2 μg g^{-1} cheese. *Lb. wasatchensis* was detected by PCR with species-specific primers at 3 and 13 weeks of aging when NSLAB were 10^6 cfu g^{-1} and 10^7 cfu g^{-1} , respectively. *Lb. wasatchensis* appears to accumulate as cheese made at this facility ages. Variation seen in the DNA yields and in *Lb. wasatchensis* detection may be due to heterogeneity in the cheese and to changing chemical and physical properties that occur during aging. Further work to develop more sensitive detection techniques, including microbiome analysis, will allow us to better understand the growth dynamics of this organism, which will help us develop

modifications to the cheese aging process to control the development of NSLAB in Cheddar cheese.

BIOLOGICAL SCIENCES

Optimization of Adjunct Lactic Acid Bacteria Cultures for Flavor Production in Dry Salted Gouda Cheese

Dillan Gardner, Craig Oberg, Matthew Domek, Michelle Culumber, Donald McMahon

Weber State University

Diacetyl, formed by the fermentation of citrate by some lactic acid bacteria (LAB), is a butter-flavored compound found in dairy products, such as cheese and yogurt. During Gouda cheese manufacture and aging, citrate is fermented by some LAB to diacetyl, which adds to its characteristic flavor. In this study, we characterized LAB that produce diacetyl as potential adjunct cultures that could be added during Gouda cheese manufacture to produce this flavor. In traditional Gouda production, the curd is soaked in brine then pressed into a block. An alternative method is to dry salt the curd first and then press it into a block, which would require adjunct LAB cultures to be more NaCl tolerant. A number of LAB isolates were characterized for the ability ferment citrate to diacetyl and for salt tolerance. Since the final concentration NaCl of Gouda cheese is 4%, isolates were grown in M17 lactose broth with NaCl concentrations of 0, 3, 4, or 5%. A colorimetric assay was used to determine diacetyl production at these NaCl concentrations. Six isolates (*Lactococcus lactis* ssp. *lactis* biovar diacetylactis 810, *Lc. lactis* ssp. *lactis* biovar diacetylactis 810, *Lc. lactis* ssp. *lactis* biovar diacetylactis 810LD2, *Lactobacillus* sp., *Leuconostoc meseteroides* 10.00, and *Leuconostoc citrium* 160) could grow and produce diacetyl above a 4% NaCl concentration with an average diacetyl concentration of 4–6 µg per ml. One culture, SD5, produced the highest level of diacetyl, almost 6 µg over 6 days. All six strains appear to be good candidates as flavor-enhancing adjuncts for the manufacture of dry-salted Gouda cheese, with SD5 as the best candidate. Gouda cheeses were made using these 6 cultures in the cheese and further analysis is required to determine levels of diacetyl.

BIOLOGICAL SCIENCES

Alkali Bullrush: A Forgotten Food

Stephen L. Clark

Weber State University

When the colonists first landed on our eastern shores, it is estimated that Native Americans were using ~300 different species of plants for food. Recent archeological digs in British Columbia show people living along the coast were also using dozens of native species for food. Today, most of our food comes from 12 plants, all of which are non-endemic to North America. Alkali Bullrush (*Scirpus maritimus*) is a plant that grows in temperate regions on every continent except Antarctica. Historically, indigenous people used it for food. It grows in habitats where other plants usually considered important for human consumption will not grow and has the potential of providing a new source of food for a hungry world. It grows best in wet, heavy, alkaline soils, with standing water in the spring, followed by a drier summer, much like domestic rice. In its natural state, it produces an average of 15 bushels of grain/acre and produces more energy, oil, protein, and calories per gram than wheat. One problem with its potential use is that the seed coat is very hard and requires more energy to grind than wheat or rice. This presentation will discuss the plant's ecology, cytogenetics, ethnobotany, use by wildlife, stream stabilization properties, germination requirements, and seed production. Flour made from the seeds makes tasty pancakes and muffins.

BUSINESS

The State Treasurer Needs an Intermediate Maturity Fund: A Discussion of Investment Options Needed to Compliment the PTIF

R. Neil Walter (Independent Researcher), Nathan G. Caplin

Snow College

The Treasurer's office has focused on the performance of the PTIF while its participants have been depositing long-term cash in the Treasurer's short-term investment vehicle. Sophisticated state entities invest longer-term on their own. It is time for the Treasurer to put together an intermediate maturity fund that would create a higher return investment

option for counties, cities, school districts, universities, charter schools, and other entities of the state that do not have the ability to manage a similar long-term investment strategy. The combination of the existing PTIF and a new intermediate maturity fund could materially increase cash dividends to the fund participants without requiring the Treasurer to take on additional credit risk.

BUSINESS

The Farmer and the Cowman Should be Friends

Chelsea Dye, Jennifer Harrison, Ron Mano

Westminster College

In 1972, the late Dr. Robert R. Sterling gave a speech about “Accounting Power” at Oklahoma State University (Bob is a native Oklahoman). Parts of that speech was later published in the July 1972 issue of the Oklahoma CPA journal and in the January 1973 Journal of Accountancy. In that speech, Bob Sterling is quoted as saying, “Managerial accountants and public accountants are adversaries in the same way that opposing lawyers in a trial are adversaries.” Forty-six years of history since that speech has proven the statement to be prophetic. Although the statement has proven to be true, it is a condition that should never exist in the accounting profession. Dr. Sterling states, “The objective of the public accountant is, or ought to be, to tell it like it is.” Dr. Sterling often talked about “truth in accounting.” We believe that it just as much be the managerial accountants’ objective to “tell it like it is” as it is the public accountants’ objective to do that. As is professed in Rodgers and Hammerstein’s “Oklahoma,” the Farmer (the managerial accountant) and the Cowman (the public accountant) should be friends. The Accounting Profession has coined a phrase “management fraud” that seems to be an attempt to distance ourselves from fraudulent financial reporting. Much has been written about Public Accountants who have gotten into legal trouble for having missed finding fraudulent financial statements. However, this group of authors believe that management is not capable of producing fraudulent financial statements without the participation of an in-house (managerial) accountant. This research study includes an analysis of cases in which managerial or in-house accountants failed to insist that the financial statements “tell it like it is” and became criminals because of that activity.

BUSINESS

Comparative Workplace Orientations and Conditions in the U.S., Western Europe, and Nordic Countries

Jonathan Westover, Colton Harris, Jace Johnson, Jake Epley, Blaine Dudgeon

Utah Valley University

The vast cross-disciplinary literature exploring worker attitudes and workplace conditions has linked worker experiences to many individual, organizational, and social outcomes, yet this research has largely failed to shed light on why cross-national differences in worker satisfaction and engagement and their determinants persist over time. Cross-cultural researchers suggest that these differences are due to cultural differences in each country. However, this approach has largely neglected to show that countries with similar cultural orientations still experience significant differences and related challenges. Thus, the question remains, what are the causes of these differences and what are their long-term impacts of sustainable economic development and labor prosperity? Moreover, much research has been conducted that shows either the general improvement or decline in the quality of work, but few studies have looked at such changes in work quality cross-nationally, over time from the perspective of the workers, and while accounting for country-contextual characteristics. This research utilizes attitudinal data from the International Social Survey Program 2015 Work Orientations module, cultural variables from the GLOBE project, and country contextual geopolitical and economic data to examine and explore the cultural, political, and economic structural factors impacting the labor transformation in the U.S., Western Europe, and Nordic Countries.

BUSINESS

Facilitating Workplace Unity through Conflict and Communication

Annalyse Kofoed

Utah Valley University

This paper starts with my working thesis: companies should encourage the reduction of prejudice and bias in the workplace by cultivating a people-oriented culture wherein victims can feel safe to confront

perpetrators and perpetrators can feel safe to recognize a fault and grow past it—both parties being safe from retaliation or shame. Such a thesis is novel in the academic field because a large part of the existing diversity initiatives and research are conducted in hopes of preventing conflict in the workplace; this thesis, on the other hand, moves to embrace conflict and use it advantageously in overcoming diversity issues and facilitating long-term harmony. However, the thesis is focused on the metaphorical gray space between illegal discrimination (which should be dealt with in the legal context) and healthy, positive interactions. It's the space of teasing and mocking that can be harmful, and this can also include the concept of microaggressions. In regard to the content of this project, a variety of academic resources will be utilized and presented to examine the psychology behind the moment of confrontation on the sides of the victim and perpetrator; this includes what costs and benefits are weighed when deciding to confront and how the nuances of that confrontation challenge the perpetrator's schema of being a decent person. Afterward, I will also discuss existing business practices and cultures that enable an active education as it relates to revealing implicit biases and reducing such bias in the workplace. Limitations to the business practices and cultural recommendations I will provide include the likely possibility of employees who resist such initiatives and cultural changes; however, there are existing theoretical models that help provide insight into overcoming these limitations (which will also be discussed).

BUSINESS

Is Social-Cause Marketing an Effective Strategy for Big Brands on Social Media?

Kendra Jorgensen, Paige Gardiner

Utah Valley University

Brand exposure and social media marketing engagement are extremely valuable to brands. Whether customers agree with controversial social-cause marketing, big corporate brands are starting to take a stance on social-cause issues on a regular basis. Brands are finding the opportunity to become humanistic by having opinions and feelings towards current social-causes. Through video advertisement, brands across several industries have entered into social-cause marketing. From Dove with Proctor and Gamble, to Nike, and Always, each brand is trying to influence society in some way by touching on subjects of police

brutality, breastfeeding in public, and gender equality. Through the use of video advertising and social media channels, these brands are creating controversial social-cause content, and their customer can't help but engage in the conversation. Youtube and Facebook are the top platforms used to show these social-cause advertisements and invite conversation and engagement from all sides and opinions. These conversations keep the brand relevant and top-of-mind for customers, but is this a good brand marketing strategy? How are these brands affected by their social-cause advertisements? Do brands gain more exposure if they advertise an opinion on a social-cause issue? Gillette, Nike, Pepsi, Yoplait, AirBnb, Procter & Gamble, Stella Artois, and Always are brands that have created controversial video ads and voiced opinions about social-cause issues over the past few years. The researchers captured the Youtube and Facebook views and engagements metrics from the social-cause advertisements and correlated the metrics with the respective financial performance of the brands to determine if marketing on social-causes are viable branding strategies. The researchers provide discussion and recommendations for how brands can effectively use social-causes as a branding marketing strategy.

BUSINESS

A Social Impact Evaluation of Project READ

Andre Oliveira, Ronald Miller

Utah Valley University

Project READ is an adult literacy program in Utah that offers tutoring services to help individuals improve their reading and writing skills. It aims to transform students' lives by giving them the opportunity to meet personal goals, function well in society, and transition to higher education and improved employment, thereby becoming more productive citizens. In this paper, we describe how an evaluation of Project READ was designed to assess its social impact. We identify the project's main stakeholders, develop a theory of change, assess data and time constraints, and produce descriptive statistics from baseline data. We also carry out a basic statistical analysis of the project's impact using student data that includes demographics and test results. The evaluation of Project READ has not been implemented yet, and will likely take several months. We outline each stage of the evaluation and discuss the quantitative and qualitative methods that are appropriate for each stage.

BUSINESS

Validating Social Media Strategy Frameworks Using Luxury Car Facebook Campaigns

Paige Gardiner

Utah Valley University

Effectively using social media to market a product or service is an evolving challenge for many marketers because of the vast possibilities to connect with customers. Parsons and Lepkowska-White (2018) created a four-dimension framework used by marketing managers when creating and implementing social media marketing strategies. The four-dimensional framework includes messaging/projecting, monitoring, assessing, and responding. The purpose of the study was to use the Parsons and Lepkowska-White framework as a theory to examine and describe seven luxury car brands' Facebook social media marketing campaigns during March 2018. Using a content analysis approach, the researcher described and analyzed how the luxury car brands used different social media marketing strategies and tactics in accordance to the Parsons and Lepkowska-White framework. The researcher compares the success of the social media marketing campaigns and evaluates the social media posts to the social media marketing theoretical framework for effectiveness. The study contributes to the literature by offering a conceptual and empirical validation of possible social media marketing strategic frameworks.

EDUCATION

(Don't) Just Tell Me What to Change: A Practical Approach for Implementing Self-Directed Learning into Student-Instructor Conferences

Katie Johnson

Brigham Young University

Student-instructor writing conferences are odd environments, especially considering the switch from teacher-led classrooms to student-led, collaborative, and self-directed classrooms (Bruffee, Trimbur, Ambrose, Pajares and Valiante, Dunlap and Grabinger). Usually, conferences are anything but collaborative and self-directed; teachers often give students advice on specific ways to improve their papers and students passively

receive that advice with little input or thought of their own (Black, Arbur, Karliner, Park, Wilder). My pedagogical strategy hopes to reshape and disrupt the hierarchal, teacher-led environment of these conferences through self-directed learning (SDL), a process in which individuals take the initiative...in diagnosing their learning needs, formulating learning ...and evaluating learning outcome's (Knowles 18). With semester-long preparation including metacognition, reflection, and self-efficacy exercises, my first-year writing students foster their SDL through directing their last student-instructor conference: students set goals for the writing conference, they decide in advance what they want to discuss, they guide the conversation and do most of the talking during the conference, and they later reflect on their conference's outcomes. The instructor acts as a recorder of the conversation and as sounding board for the students' ideas. I found that this method allows students to generate their own solutions for problems in their papers, brainstorm ideas, evaluate their own learning needs and strengths and weaknesses, and build self-efficacy for writing in general, not just for their specific assignment. At the The Utah Academy of Sciences, Arts, & Letters Conference, I hope to present my pedagogical approach, materials, and results from a limited case study using this method.

EDUCATION

Utah State Capital Resource Allocation: A Proposal for Increasing the Transparency of Capital Expenditures, Including Facilities

R. Neil Walter, Nathan G. Caplin

Snow College

Capital expenditures are a unique challenge in state budgets because subdivisions of the state are rarely charged for using the state's debt or equity for facilities, equipment, and other investment needs. In an effort to take advantage of the current resource allocation process, state subdivisions lobby for capital expenditure appropriations. The result is an inefficient distribution of resources for capital expenditures within state budgets where the most connected, best-funded lobbying efforts frequently win. This paper proposes changing the capital resource allocation processes by attaching a cost to state-appropriated capital expenditures in an effort to increase accountability and efficiency while improving the long-term credit strength of the state.

EDUCATION

The Role of Practitioner Research in Teacher Professionalism

Joel Judd, Betty Jepson, Christina Hurley, Erica Fordiani

Southern Utah University

The modern history of practitioner-as-researcher can be traced from Dewey (1929), to the emergence of action research (Lewin, 1951), conceptualizations of the practitioner–researcher (Cochran-Smith and Lytle, 1993), and recent claims that teacher professionalism centers on practices that are informed and improved by and through teacher [practitioner] research (Sachs, 2016, p. 424). This presentation begins with the development of a new teacher research-focused M.Ed. program and its impact on participant teachers. Evidence shows asking and answering personally relevant questions empowers educators and promotes qualities of teacher–leaders (Vaughn & Burnaford, 2015). Three current candidates will each share their experiences designing and carrying out practitioner research projects. Their stories evidence the professional insights, benefits, and changes that stem from critically reflecting on one's work (Sockett, 1993).

EDUCATION

Taking the Plunge: A Review of Faculty in Utah who Ran for Legislative Office in the 2018 Election

Peter Kraus

University of Utah

This will be a review of all House and Senate races of the Utah Legislature where those employed in higher education ran for office. Political affiliation, status of employment (staff or faculty rank), and other variables will be examined. The underlying question to be examined, did individuals who ran for legislative office make a difference in the election?

EDUCATION

Exploring the Effects of High-Impact Practices on the Traditionally Underserved University Student

Jonathan Westover, Rasha Qudisat

Utah Valley University

Using data on all UVU new enrollees between Fall 2009 and Summer 2013, we have compared the effectiveness of certain programs on students who self-describe themselves as American Indian, Alaskan Native, Native Hawaiian, or Pacific Islander. A total of 659 students in our sample fall under that criteria, with 272 describing themselves as American Indian or Alaskan Native and 387 describing themselves as Native Hawaiian or Pacific Islander. Their information is not included in this data, but as of 2016 UVU had 290 American Indian/Native Alaskan students and 291 Native Hawaiian/Pacific Islander students. We have compared the GPA and graduation rates of these students against those of students of all other ethnicities. The results of this data show that these students of interest have lower graduation rates (9.6% vs 23.3%; $\hat{I}\ddagger 2(1) = 68.246$, $p < .001$) and lower GPAs (mean difference (md) = $-.629$, $p < .001$, 95% CI = $[-.715, -.544]$). The number of students in the sample used to calculate average cumulative GPAs is slightly lower due to a few missing values.

EDUCATION

Intersection of Math, Art, and GeoGebra

Violeta Vasilevska

Utah Valley University

In this presentation, a math-art project that includes explorations with GeoGebra software will be described. The presentation will display how art and technology can be integrated as an in or out of math class project. It connects math (in particular geometry), origami, exploration with GeoGebra software, and art. First, some simple origami folds will be shown and the math behind them will be discussed. These origami moves produce tangents to some curves. This construction will also be demonstrated with GeoGebra software, and then used to construct some interesting art pictures. The project was used at a regional STEM conference for junior-high female students, but part of this project could be adapted to different college classes.

EDUCATION

The Impact of Service-Learning on Student Learning, Engagement, Retention, and Completion

Jonathan Westover, Rasha Qudisat

Utah Valley University

This study examined involvement in service-learning (SL) by students at Utah Valley University (UVU). In particular, the study involved seniors at the undergraduate level. Each student participated by taking the National Survey of Student Engagement (NSSE) and were measured on the 10 competencies relating to student engagement. A comparison was made between non-SL seniors and SL seniors and their relating demographics. Another aspect the researcher assessed was graduation rate as well as retention. Results indicated that SL seniors performed better relating to certain NSSE competencies as opposed to their non-SL senior counterparts. This included Reflective and Integrative Learning, Student–Faculty Interaction, and Collaborative Learning. In addition, SL seniors had a higher rate of graduation in comparison to non-SL seniors.

ENGINEERING

Applications of Aluminum Foam

Christopher J. Bettencourt, Victoria A. Krull, John R. Webster Jr.

Southern Utah University

Despite a relatively young history, metal foams have already had an extensive impact on the industry. With ties to military defense, automobile safety, and jet engine sound dampening, metal foams have been optimized to successfully withstand strenuous circumstances. Applications of metal foams in the industry have led to increased safety, superior mechanical properties, and versatility in recent years. This research paper specifically looks at the sound dampening and energy absorption qualities of Aluminum A356 Foam, through compression and acoustic testing.

ENGINEERING

Heat Transfer Analysis of Water During Liquid–Solid Phase Change

Colton Robinson, Cameron Aston

Southern Utah University

To better understand heat flow through materials undergoing a phase change, experiments were conducted on water during the freezing process. Water was placed in a cylinder and cooled from the outside surface of the cylinder utilizing a counter-flow heat exchanger. The heat exchanger provided cooling at constant temperature from the fluid flow of a constant-temperature bath system. The phase change analysis system was designed to promote a phase change (solidification) in the inward radial direction. Since the top surface of the water was exposed to the atmosphere, it began to freeze first. However, the frozen top surface provided enough insulation to slow the freeze front from the top surface to a negligible speed. As such, the experiment was considered to be one-dimensional heat transfer in the radial direction. The experiment revealed that the heat was transferred in the radial direction on the water below the top surface. The experiment also showed that a steady temperature of 0°C was achieved before freezing occurred. Along with evaluating the freezing process of water, this experiment verified that the system is operating as intended and that further tests can be performed with eicosane as the phase change material.

ENGINEERING

Measuring the Thermal Conductivity of Air

Jake Sip, Andrea Lauren Reeder, Dallin Giles, Ali Siahpush

Southern Utah University

Josef Stefan was a 19th-century scientist who was well known for his work in heat transfer. With the use of his apparatus, the diathermometer, he was the first one to experimentally evaluate the thermal conductivity of air. In this research at Southern Utah University, the work of Josef Stefan was advanced through the building and experimentation of diathermometers. By submerging the diathermometers in an ice-water bath and measuring the pressure and temperature over time, the thermal conductivity of air can be determined. Three diathermometers were designed and constructed. Several tests were performed, and the data

from diathermometers were analyzed to evaluate the thermal conductivity of air. Finally, the results were compared with the published values of the thermal conductivity of air as a function of temperature. The results had some consistent error when compared with published values. This suggests a systematic error.

ENGINEERING

Open Source Antenna Pattern Measurement System

Daniel Newton, Christian Hearn

Weber State University

The Weber State University Department of Engineering is integrating a software-defined radio (SDR) link to a portable, motor-controlled antenna positioning system. The project is supported through the Utah NASA Space Grant Consortium. The wireless testbed will trade limited measurement accuracy for a cost-effective, open-source, reconfigurable platform. The automated antenna measurement system will be an educational resource suitable for introductory antenna characterization. Preliminary measured antenna patterns will be presented. It is anticipated the SDR wireless channel will permit the investigation of communication parameter performance (e.g., multipath, fading, narrow- and wide-band noise interference).

ENGINEERING

Rehabilitation of Bridges under the Umbrella of Recent Management Techniques by Using Performance-Based Design Model

Mohamed Askar, Jacob Bishop, Aaron Lewis

Southern Utah University

There are more than 54,000 bridges in the United States that need to be repaired or replaced. Bridges had been subjected to constant, sustainable, and sequential progress in the last decade. The need to extend the service life of existing prominent bridges and a better perceptiveness of the deterioration mechanisms in concrete has led to efforts to develop a rational methodology for the maintenance of concrete. In this paper, the subject of maintenance of concrete bridges has been treated in general

manner, so that the document can be employed as a basis for developing specific quantitative parameters, specifications, and manuals for different concrete bridges. The paper imparts the rehabilitation of an under-construction regional bridge as a case study for applying the suggested maintenance system. It presents the outline of the design system for the bridge retrofitting on the basis of the performance-based design to satisfy an adequate required level with respect to all required performance items including structural safety and serviceability. An impersonal evaluation technique that is relevant to value engineering is implemented to express the convenience of the repair method. An appropriate rehabilitation method was selected among various alternatives and the performances of the retrofitted bridge by the selected method are verified with required performances after retrofitting until the end of service life considering time-dependent performance deterioration. The concept is to convert any criteria involved to measurable values on the same scale, whether the decisive factor is structural integrity, ease of construction, sustain of traffic service, environmental hazards, and repairs cost. Steps forward in numerical analysis techniques and evolution of precise simulation method is a powerful tool, it releases the doubtful sense of the designer to the requirements of his structures taking into account the required precision of the constitutive modeling and its construed parameters.

ENGINEERING

A Simple Approach to Evaluate Thermal Conductivity of Solids

Lloyd Stephens, Austin Becker, Reece Alvarado, Ali Siahpush

Southern Utah University

This paper is the fourth-generation, ongoing experiment at Southern Utah University to experimentally and analytically evaluate the thermal conductivity of a specific solid and compare the result with the published value. The solid used in this experiment was UHMW plastic. Multiple tests were performed on this material to prove that results within 2% of the published value can be achieved through utilizing an insulated short cylinder with a large diameter. This configuration simplified the evaluation and justified the radial one-dimensional heat transfer analysis. This configuration can also be used to test the thermal conductivity of other circular solids.

ENGINEERING

Airglow Measurement Trends from the SABER/TIMED Satellite over a Solar Cycle

Brian Simons, Doran Baker, Gene Ware

Utah State University

Airglow emissions in the terrestrial mesospheric region have been studied using a multi-channel infrared radiometer flown aboard a NASA polar-orbiting artificial satellite. The infrared airglow emissions of interest in the present study have included hydroxyl, molecular oxygen, ozone, and nitric oxide. Particular attention has been given to the dynamic trends over the solar cycle and a half since measurements were first obtained in January 2002. The radiometer scanning is achieved by the satellite orbiting to give three-dimensional measurements, horizontally by the circumpolar motion of the satellite, and vertical measurements are obtained using an oscillating mirror to give scans from horizon to near space. Although the airglow of prime interest comes from layers in the mesosphere, sometimes multiple layers are observed. However, in this paper, attention was restricted to “normal” single layers in the mid-range of the mesosphere. The processing includes examining peak radiance and altitude, both geographically and in relation to the Sun. Possible trends are examined over the course of one and a half solar cycles. Correlations are drawn between the observed emission species.

ENGINEERING

An Optimized Lens-Into-the-Body for Passive Beamforming

Cody O'Brien, Chris Trampel

Weber State University

Small radiofrequency (RF) telemetry systems are the means of communication for wireless body area networks incorporating implantable medical devices (IMDs). Most current IMDs communicate with a base station via a transmitter powered by a battery. There are a number of drawbacks to these active communication systems. Implantable antennas are inefficient radiators because of their small electrical size. As a result, a significant fraction the energy budget of the device must be dedicated to communication. The battery is quickly

depleted and must be recharged. Implantable transmitter performance is further limited by specific absorption rates in the body. Radio frequency identification (RFID) is an attractive alternative to the state-of-the-art. This presentation describes progress toward the design and fabrication of a wearable metasurface sensor, the lens-into-the-body, designed to increase the read-range of a medical RFID system. This project has two phases. Phase I consists of the optimization of the lens. A binary optimization scheme and genetic algorithm used to design a lens that focuses energy on the implant is described. For a given geometry, Maxwell's equations are solved numerically using a hybrid-finite element mode-matching algorithm that includes an absorbing boundary condition. An objective function capturing the energy delivered to the implant is extracted from the simulation. Lens prototypes will be fabricated and tested during Phase II. Fabrication of the lenses will be accomplished with a 3D electronics printer. S-parameter measurements to characterize the performance of the lens will be made.

ENGINEERING

Autonomous Surveillance Drone

Cody Glad

Weber State University

Soldiers are vulnerable while moving through the battlefield and need reliable real-time information to navigate safely. The author is developing an autonomous drone to gather, compile, and convey this information to the soldier in real time. This drone will be custom built from a bare frame and custom parts and be coded from scratch. The drone will be able to pilot itself while following a GPS signal that is sent from a control box. The drone and control box will be outfitted with radio modules that will allow for wireless communication for up to 800 meters. It will be outfitted with an ultrasonic sensor array to detect, avoid, and navigate around hazardous obstacles. The drone will have a function that allows the user to select a location and have the drone go to that location to collect information. Along with the drone, a control box will be developed. This box will connect to the drone through a radio module and display some basic information and be able to send commands. The interface between the drone control box and the drone will be very minimal. The soldier can specify a following distance and a desired height and send some basic commands such as landing, staying still, following the drone control box, and going to a specific location. Outside

of these commands, the drone will pilot itself while continually avoiding obstacles. This will enable soldiers to safely collect information about their surroundings in real time.

KINESIOLOGY AND HEALTH SCIENCES

A Prophylactic Treatment in a Rat PTSD Model Examining Plasticity of Brain Regions Altered in this Disorder

Eliza Neal, Spencer Kimball, Jeffery Edwards, Roxanne Miller
Brigham Young University

Post-traumatic stress disorder (PTSD) is a complex anxiety disorder that affects about 1 out of 4 individuals after a traumatic experience. Victims of PTSD are often found with increased levels of catecholamines (adrenaline) and corticosteroids—hormones that increase plasticity in the memory and emotion regions of the brain. While one approach to treating PTSD is to give receptor antagonists for these hormones after a trauma has occurred, our research examined the use of hormone receptor antagonists—propranolol and mifepristone—prior to the trauma in an attempt to prevent PTSD onset. To study the efficacy of these antagonists, a social defeat (SD) model was introduced. The use of the SD protocol is significant as its inclusion of social interaction mirrors the social aspect of human PTSD. To mimic the formation of memories, we performed field electrophysiology experiments in the brain slices of SD and control rats, measuring long-term potentiation (LTP), the cellular mechanism mediating learning and memory. In PTSD, LTP is usually altered in the emotion and learning centers of the brain including the ventral hippocampus (VH), lateral amygdala (LA), and medial prefrontal cortex (mPFC). Results demonstrated that SD caused a significant increase LTP in the VH, LA, and mPFC. Finally, to determine whether a prophylactic treatment could prevent the physiological changes of PTSD (i.e., increased levels of LTP), we simultaneously administered propranolol and mifepristone at 10 mg/kg doses by intraperitoneal injection one week prior to and throughout SD. The levels of LTP returned to control levels in the VH, LA, and mPFC of SD rats that received drug injections when compared with SD rats with no drug injections and controls. Overall, our data suggest that propranolol and mifepristone together may be a viable prophylactic treatment for preventing PTSD. This could be beneficial to those who are susceptible to experience PTSD.

KINESIOLOGY AND HEALTH SCIENCES

Managing College Stress: Perceptions and Physiological Effects

Shirley A. Dawson, Michael Olpin

Weber State University

Stress has become the number one health problem for many adults (American Institute of Stress, 2016), and college students seem particularly vulnerable to stress and its negative physiological effects. Despite the overwhelming presence of stress, few university options are available to reduce stress or provide methods to cope with stress. The primary objective of this study was to determine the impact a university stress relief center on students' stress and well-being as measured by heart and blood pressure rates and perceptions of stress and pain. From 2008–2016 data from almost 12,000 university students who voluntarily visited a university stress relief center were gathered. Differences between gender, stress management course enrollment, and participation length and relationships between perceived stress and pain with blood pressure and heart rate were analyzed using quantitative causal comparative post hoc methods. Significant lowering of perceived stress and pain levels and blood pressure and heart rates occurred after time spent using stress relief center tools and interventions for all students regardless of gender, course enrollment, or participation length.

KINESIOLOGY AND HEALTH SCIENCES

The Impact of Exposure to Alcoholism on Children and Adolescents: A Review of the Literature

Yan Huang

Weber State University

Objective: The purpose of this literature review was to provide a summary of the impact that exposure to alcoholism has on the health and developmental well-being of children and adolescents. **Method:** A search was conducted to analyze the available literature using keywords (alcoholism, children, adolescents, impact, outcome) to help identify important articles that were pertinent to the topic using the following databases: Academic Search Premier, ERIC, CINAHL Complete, PsycINFO, and MEDLINE. Articles published from 2006 to 2017 were

included. Results: A total of 9 articles were selected to compose this literature review. The results revealed that children and adolescents living with alcoholism are at increased risk of experiencing emotional, physical, and sexual abuse; developing emotional and behavioral problems; and facing other negative consequences in their lives. The significant impact can endure even beyond adolescence. Conclusions: The results suggested that efforts should be made to enhance the parenting awareness and capacity. Parents need guidance on effectively controlling their alcohol consumption and need education to understand the problems associated with protecting the younger generation.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

The Role and Usage of English Words in French Film

Dina Iakhina

Snow College

Foreign words constitute an important part of the vocabulary of the majority of languages. The importation of foreign words and their usage can help us to learn more about the interactions and mutual influence between the societies speaking different languages not only in the present but also from the historical perspective. This study examines the examples of the importation of English words into the French language on the example of French cinematography. We also study the reasons for such borrowings and their role and functions.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Arab and Muslim Americans: Two Diverse Minorities

Kholoud Al-Qubbaj

Southern Utah University

Two of the most rapidly growing minorities in the United States today are Arab and Muslim Americans. Yet, the continual misunderstanding of perceiving these groups as separate minorities leads to the entanglement of identities. One key identifier is recognizing that Arabs are an ethnicity while Muslims are a religious group. Muslims make up approximately

1.6 billion (about 1/5th) of the world population and follow the Islamic religion. Conversely, Arabs make up approximately 300 million (nearly the population of the United States) of the world population and stem from the geographic region of the Middle East composed of 22 countries with a native language of Arabic. Thus, the confusion seems to occur from the lack of understanding that most Muslims do not stem from an Arab ethnicity, but the majority of Arabs identify with the Islamic faith. In terms of Arab Americans, the identities present within the minority do not necessarily mirror that of the Arab geographic region. In fact, more than 75% of Arab Americans are religiously Christians of various denominations: Catholics, Greek Orthodox, Maronite Christian Church, and Coptic. The earliest Arab immigrants to the United States were, in fact, Christian. Early immigrants were often part of the working class, but in modern times are highly educated professionals and entrepreneurs who are prosperous economically when compared with other racial and ethnic minorities. Understanding the differences geographically and demographically is essential in identifying the diversity of the population that encompasses these minorities. Yet, unfortunately, negative events centering around Arabs and/or Muslims often leads to a rise of discrimination involving both identities and often extending to other related stereotyped minorities.

LETTERS—FOREIGN LANGUAGE, HUMANITIES, PHILOSOPHY

Two Imperfections in Spanish Orthography: A Suggestion for the Asociación de Academias de la Lengua Española

Tom Mathews

Weber State University

Spanish enjoys a nearly phonemic alphabet. Historically, the Real Academia, and more recently the Asociación de Academias, have made changes as necessary to reflect changing pronunciation and to make the spelling system ever more logical and consistent. The use of accent marks was nearly (but not quite) perfected in 2010. However, the use of the letters «g» and «j» was officially confounded by the early 19th century and has not been revisited. In this essay I make two suggestions: (1) use an accent mark on three stressed monosyllabic words—*lá*, *sí*, *mí*—when they refer to musical tones. This would make universal the practice of using a tilde on stressed monosyllables when an unstressed

word, otherwise spelled the same, also exists; and (2) regularize the use of the letters «g» and «j» to represent the phoneme /x/. Spanish now uses "g" to represent the historical shift of the phoneme /g/: that is, /g/ → [x] / ___ [+vowel, +anterior]. Spanish uses the letter «j» to represent the late medieval shift of the palatal voiceless fricative to a velar fricative: /ç/ → /x/. Since few modern Spanish speakers know the etymological distinction between the «g» in *coger* and the «j» in *mujer*, I recommend that the orthography be regularized. Documented examples to illustrate each of these proposals will be shared.

LETTERS—LANGUAGE AND LITERATURE

‘Reason Is but Choosing’: Navigating Reason, Choice, and Obedience in Milton’s *Paradise Lost* and ‘Areopagitica’

Amber Bird

Brigham Young University

In *Paradise Lost*, the relationship between God and man is unfolded as Milton acknowledges his aspirations to “justify the ways of God to men” (1.26). Rather than approaching God’s vindication with prose and argumentation, Milton employs the Biblical narrative “of Man’s first disobedience” in an epic poem (1.1). Milton uses the story of Adam and Eve and the principles he articulated in “*Areopagitica*” to argue that the Edenic narrative could not have been complete without the confrontation with choice. Choice is but reason, and reason comes from God. Evidence from Milton’s “*Areopagitica*” highlights how an encounter with choice was necessary to and mandated by the way God created Adam and Eve, and that reason given from God justifies the actions of Adam and Eve that propelled them into a fortunate fall.

LETTERS—LANGUAGE AND LITERATURE

Martin Espada and the Political Power of Poetry

Christopher T. Althoff

Brigham Young University

As part of the Frankfurt School, Theodore Adorno subscribed to a Marxist criticism of capitalism. While Marx viewed history through an

economic lens, Adorno looked at society through a cultural lens hoping that it would explain the complacency of the US working class. Media like literature, film, music, and the finer things normally considered “art” became products to be sold. Adorno called this act of turning art into merchandise the culture industry, and he was not a fan. Art for Adorno created meaning and made people ask questions about their perceptions of the world: it should be thought-provoking. The culture industry created “art” to make money. Adorno knew that the culture industry is created to meet the desires of the audience so they would have a certain level of happiness and be comfortable. Many writers share Adorno’s desire to take art back from the culture industry. One of these resistance writers is Martin Espada, who sees poetry as a form of rebellion. In *The Republic of Poetry*, Espada shows how poetry can be used as a tool of resistance to empower the average man to become more than a cog in the capitalist machine.

LETTERS—LANGUAGE AND LITERATURE

Two Irish Poets and a Mummy Walk into a Pub...

Rob Carney

Utah Valley University

A good poem is always about more than its occasion. Seamus Heaney’s “Punishment,” for instance, jumps from observations about a woman’s mummified remains to an indictment of himself and Irish Catholics during *The Troubles*. He sees no difference between the Iron Age and his own, and little difference between mob violence and standing by and letting it happen. The past and present get wound together like wrappings around a mummy. The contemporary female Irish poet, Paula Meehan, does something similar in her poem “The Pattern.” Hers, however, is more familial and personal, and it is more wide-ranging. How perfect, then, that she chooses sewing and weaving rather than wrappings as her metaphor, and pieces her episodic stanzas together like a quilt. I will discuss both poems, of course, but also share Meehan’s poem aloud in its entirety because Meehan, like Eavan Boland, was at the forefront of a group of Irish women poets in the 1980s taking charge of writing their own stories rather staying in the cultural shadows. They were not content to be emblems and subjects in Irish poetry authored by men. They wanted to speak as and for themselves. And because Heaney’s poem is provoked by the discovery and showcasing of mummies exhumed from

bogs in northern Europe, I will tell you some true things about mummies you wouldn't believe.

LETTERS—LANGUAGE AND LITERATURE

Dueling Heroes: Contrasting Hero Journeys in Shakespeare's *As You Like It*

Patrick Lynch

Dixie State University

Referencing the Hero's Journey archetype detailed by Joseph Campbell in his *A Hero With A Thousand Faces*, I propose to measure the adherence to the Hero's Journey model of the two central characters—Rosalind and Orlando—in William Shakespeare's *As You Like It*. Through a comparison of the respective heroism of the two characters, one better understands the transformation of each character during the course of the play, together with the rich ways the characters shape the play's larger social concerns.

LETTERS—LANGUAGE AND LITERATURE

Ethical Responsibilities of Standard English Speakers toward Users of Black English Sub-Dialects

Edgar Corrales

Weber State University

Nonstandard dialects often dictate the feelings that arise in an individual towards the speaker; the standard-speaking population may enforce this type of prejudice by affiliating a given speaker with a stereotyped social group. With our rapidly increasing e-world, the prevalence of dialect discrimination has never been more widespread and yet so subtle. The terms prejudice and discrimination should be distinguished, particularly within the context just described. Prejudice is a particular set of feelings towards an individual or a group of individuals based solely on membership within a particular group and is often associated with ethnocentrism, while discrimination is a prejudicial act towards an individual or group. Like every other form of discrimination, language-based discrimination may take on a variety of forms; these forms may be direct and indirect—and may thus lead to the deprivation of multiple

material or non-material possessions, goods, or rights. To prevent the divestment faced by black English sub-dialects marked as politically, socially and culturally inferior, the author of this paper proposes four ethical duties of speakers or users of the politically “superior” dialect: 1) abolish negative connotations; 2) implement ethical use of language; 3) move beyond the proper and non-proper way of speaking English, and 4) acknowledge and encourage written literary works in non-traditional dialects.

LETTERS—LANGUAGE AND LITERATURE

How Past Narrates the Present in the Letters of Phillis Wheatley and Harriet Jacobs

Sarah Vause

Weber State University

Epistolary writing served as the vehicle through which oppressed women, in particular slave women and later, free black women, were able to protest the injustices of their time. In this paper, I will explore representative letters of Phillis Wheatley, who was among the first black women to call the practice of slavery and the destiny of the black American into question, and Harriet Jacobs, who knew firsthand the terror occupying the space and psyche of the black woman slave. The horrific narrative created by the letters of these two women is underscored by their personal stories. Through them, a new and truer American narrative emerges, a narrative impelling the nation toward greater sensitivity to and extended rights for all Americans.

PHYSICAL SCIENCES

CCD and GAIA Observations Indicate That the Double Star System WDS 0222+2437 Is Not a Binary System

Hamza Samha , Jonathan Ginouves, Taime Clark, Savana LeBaron, Jasmine Tapia, Micah Jackson, Cameron Pace

Southern Utah University

At Southern Utah University Psychics department, the Great Basin Observatory telescope was utilized to observe the Double Star System WDS 0222+2437. AstroImageJ software was used to separate the images

of the star, as well as the position angle. The separation measured in arcsecond was compared with past observation. We found that over the span of several decades it has decreased. Also, the position angle of both stars has noticeably decreased. With this information as well as the proper motion and parallax data that was found in the Gaia database, it can be concluded that these stars are not gravity bound and not close enough to be a binary system.

PHYSICAL SCIENCES

Core-Collapse Supernova Light Curves

Morgan Taylor, Wesley Even, Ryan Wollaeger

Southern Utah University

Core-collapse supernovae are challenging phenomena to simulate realistically from first principles. Light curves from such events provide an abundant source of data, helping to constrain theoretical models. They can be used indirectly to determine the possible kinetic energies, masses, and compositions of the explosion outflows. In this project, we take a suite of core-collapse supernovae models with various explosion energies, and post process to generate light curves. The progenitor masses used are 15, 20, and 25 MS. We use the radiative transfer code SuperNu to construct the light curve data. We then compare our results with observed core-collapse light curves to identify realistic explosion models from the suite.

PHYSICAL SCIENCES

Fabrication of Copper Nanoparticles

Zhuoling Chen

Southern Utah University

The most common current methods of fabricating copper nanoparticles all involve using (small) copper ions to make (relatively large) copper nanoparticles. Most copper nanoparticles made using these methods are not stable over long periods of time. We found a new way to synthesize copper nanoparticles, starting with a copper foil (a very large piece of copper) and sonicating it in hydrochloric acid. Using UV-Vis and fluorescence analysis as well as atomic force microscopy, we were able

to determine that we made copper nanoparticles. Additionally, these nanoparticles are stable over long periods of time. Thus, we have developed a method that goes in the opposite direction of previous methods (bigger to smaller, rather than small to big) and makes nanoparticles that are more stable than those made by other methods. We are currently further exploring the properties and fabrication of these nanoparticles.

PHYSICAL SCIENCES

Hydrodynamic Simulations of Turbulence in Jet Engines

Jazmine James, Brandon Wiggins

Southern Utah University

Noise production in jet engines can have important effects on avian populations. Noise and turbulence production in such engines, however, is a highly non-linear process, requiring direct simulation of hydrodynamic flows to track self-consistently. In this presentation, we explore the efficacy of using Eulerian hydrodynamic simulations to predict the noise signal from rockets by comparing simulation data to photographs of experiments. We carry out hydrodynamics with an ideal equation of state, using the FLASH hydrodynamics code. We compare our results to the literature and comment on the agreement between simulation and experiment.

PHYSICAL SCIENCES

Investigating the Light-Absorbing Properties of Dipyrrroles Common to Bilins

Clayton R. Staheli, Bridger P. Jeppesen, Jacob C. Dean

Southern Utah University

Pigments in plants give us a wide variety of color. They are very beautiful at times but also serve a more practical purpose for the plants. The dark green visible in almost all plants and algae serve the purpose of collecting light for photosynthetic processes. These green pigments are made of certain molecules called tetrapyrroles. In this project, we aim to dissect a certain tetrapyrrole that forms bilins (commonly found in algae) and observe the light-absorbing properties of a smaller “building

block” that forms this pyrrole chain called a dipyrrole. We will perform NMR spectroscopy, mass spectrometry, gas chromatography, and IR spectroscopy on said dipyrrole compound, in conjunction with previous found data, to discover the light-absorbing properties to help us more fully understand what makes the larger natural pigment so efficient at capturing sunlight.

PHYSICAL SCIENCES

Quantification of Oxygen Levels in Anoxic Environments Using a Microfluidic Device

Mariah Clayson, Maverik Shumway, Esther Harkness, Lohra Miller

Southern Utah University

Understanding anoxic environments is a relatively unexplored field of study that could have an impact on several aspects of life. For this reason, we seek to learn how oxygen levels affect a wide array of reactions by manufacturing a device that is sensitive enough to quantify low levels of oxygen and durable enough to withstand harsh environments. Recently, we have optimized designs to make a microfluidic device that is small enough to decrease reaction time, without sacrificing the durability of the device. Our designs are modeled after the STOX electrode, but we have chosen to use a PDMS microfluidic rather than glass to increase sturdiness. We also use a unique fabrication technique that allows us to create three-dimensional channels rather than being constricted to two dimensions, as are most microfluidic devices. We are currently calibrating our device and preparing it for further field testing.

PHYSICAL SCIENCES

A Deep Learning Approach to Early Cancer Detection using Near-Infrared Laser Scattering Profiles

R. Ryan Rainey, Mason Acree, Christopher Berneau, Portia Densley, Vern Hart

Utah Valley University

In the early stages of most cancers, before lesions are visible on a CT or MRI, changes begin to occur at the cellular level as nuclei elongate and

mitochondria cluster unevenly. As these organelles are responsible for much (~40%) of the optical scattering that occurs in a cell, changes in cell morphology and structure can largely affect the resulting optical signature. Variations in the physical properties of different cancer types leads to a distinct scattering profile unique to each disease. In this study, optical scattering patterns were investigated from five different cancer cell lines, which were irradiated in vitro with a NIR-1 (854-nm) diode laser. The resulting patterns were collected with a CMOS beam profiler and used to train a convolution neural network. Differences in these profiles were subtle yet significant enough to allow successful classification by the neural network. After being trained with a set of augmented images from each cancer type, the network was able to distinguish cell lines with an accuracy of up to 98.5%. The accurate classification of these patterns at low concentrations could contribute to the early detection of cancerous cells in otherwise healthy tissue. Current methods will also be discussed such as semantics and instance segmentation.

PHYSICAL SCIENCES

Gearing Up for a VASIMR Launch at UVU

**James Loveless, Michael Burt, Joshua Baum, Raymond Perkins,
Phil Matheson**

Utah Valley University

A VASIMR, or Variable Specific Impulse Rocket, is a magnetohydrodynamic rocket that has been touted as the best plausible technology for executing large-scale missions to Mars and other planetary missions. State-of-the-art VASIMR technology uses a helicon antenna to excite a plasma, which passes longitudinally along a confining magnetic field where it is further energized by ion cyclotron resonant frequency (IRCF) heating. A final magnet provides the field structure to act as a nozzle in which nearly all the plasma kinetic energy is converted into longitudinal thrust. We are constructing a small version of the device at UVU to serve as a platform for studying plasma physics. We present here the baseline physics of the device and the plasma parameters that may be produced and explored as dictated by the constraints of the device size, magnetic field strength, vacuum equipment, and RF sources, etc. The project is in its early stage, and we anticipate that it will evolve in time to provide substantial opportunities for undergraduate research. Our system currently consists of a 3-inch diameter vacuum vessel, with turbo

pump, a meter-long experimental length with two wound coils and magnetron RF source for plasma excitation, and an argon source. Studies are underway to fabricate an IRCF antenna. Undergraduate participation in the project includes instrumentation and magnet design, fabrication and characterization, software interfacing, and plasma modelling.

PHYSICAL SCIENCES

GC-MS Determination of Flux in the APEH/ACY-1 Pathway

Carson Cole, Tracy Covey, David Coffman, Nicolas Drysdale

Weber State University

Proteases play an important role in the recycling of large macromolecules down to the fundamental molecular units. Acyl peptide enzyme hydrolase (APH/APEH) and acylase (ACY) work together in recycling amino acids from N-acetylated peptides. There are biochemical approaches to studying each enzyme activity separately; however, herein we describe a GC-MS method that allows kinetic observation of both enzymes in different cell lysates. From this, we can determine individual enzyme rates and the flux through both enzymes. We have determined that three different cell lysates have different APEH activity, different ACY activity, and differing overall flux. This is potentially useful as it gives a better understanding of how these enzymes work in a cellular context, can be employed in different disease states, and suggests that there may be an unknown regulation through the enzymes.

PHYSICAL SCIENCES

Influence of Thermal Radiation of Universe on Evolution of Primordial Black Holes (PBH) and on our Ability to Detect PBH

Alexander Panin

Utah Valley University

Some scenarios of the Big Bang imply formation of primordial black holes (PBH) at early turbulent state of our Universe. Explosive evaporation of small PBH due to Hawking radiation should be

observable today, and several ongoing projects are aimed at the detection of such x-ray and gamma-ray bursts. Despite that first gamma-ray burst from space were actually detected in 1967 and currently gamma-ray bursts are detected almost daily, none of them have signatures of dying PBH. Black holes are inherently thermodynamically unstable entities—while radiating and evaporating, their temperature is increasing. PBH in space are not at zero-temperature environment—they are constantly absorbing thermal radiation of the surrounding Universe (which in turn is changing as Universe expands), get colder, and grow in mass. Therefore, their evaporation rate decreases, and they last longer than theoretically predicted age of isolated PBH. In our talk, we discuss the influence of the thermal radiation of the Universe on the evolution of primordial black holes of various mass and the limits this factor places on possibility to detect primordial black holes today.

PHYSICAL SCIENCES

Magnetic Field Modulation Toward High Energy Particle Accelerator RF Source Replacement

Clayton Williams

Utah Valley University, Jefferson Lab LLC

Magnetrons are economic radio frequency (RF) sources for driving charged particles through accelerator tunnels due to high efficiency (~80%) and low cost; however, at present, klystrons are widely used because they are linear amplifiers and have high gain, with relative lower efficiency (~50%). Replacing klystrons with magnetrons is therefore of great interest. To be suitable for driving superconducting radio frequency (SRF) cavities, magnetrons must compensate for frequency pushing when increasing gain and for SRF cavity microphonics. The most novel approach to these problems is in modulation of the magnetic field applied across the magnetron. A control scheme suitable for implementing magnetrons in precision applications requiring control over output frequency, phase, and noise is presented, including the use of trim coil magnets, filament control, and injection locking. The principles of SRF acceleration and magnetron operation are discussed and preliminary results from the Jefferson Lab SRF R&D group in magnetron control are presented. Future work, including possible commercial applications of high energy particle accelerators in waste treatment are also presented.

PHYSICAL SCIENCES

Examination of the Anti-tumor Structure–Activity Relationships of Chalcone Derivatives

**Don Davies, Tracy Covey, Parker Ferguson, Brian Farnsworth,
Brian Allen, Nick Eccles**

Weber State University

Chalcone has been reported to have anti-tumor activity. A structure–activity relationship study has been conducted to discern which components of the chalcone structure are necessary for the anti-tumor activity. Regions examined included 1) the aromatic ring at the 1-position, 2) the aromatic ring at the 3-position, 3) the alkene in conjugation with an electron withdrawing group, and 4) the presence of various types of electron withdrawing groups. Manipulation of each of these four components has led to the discovery of substrates having greater anti-tumor activity than chalcone, as well as many substrates lacking any anti-tumor activity. From these results, we have been able to conclude that the mechanism of action must involve a Michael reaction.

POSTER

Novel Small Molecule Pyrazolopyrimidine Analogues Demonstrate Anti-Influenza Activity in Vitro

Logan Edvalson

Brigham Young University

Many believe that the days of pandemic-type flu are over but fail to consider the high mutation rate of the virus. According to researchers at the Scripps Research Institute in Los Angeles, there are as few as three mutations needed for avian flu to be transmittable to humans. This would be a novel strain, much like the 1918 pandemic flu that killed up to 100 million people. The death toll from an equally deadly pandemic today would wipe out nearly 400 million. But taking into account modern air travel, the death toll would almost certainly be much higher. The dangers of flu are not limited to mass pandemics, however. Over 80,000 people in the United States alone died from flu and flu-related causes in the 2017–18 season. Influenza is a serious threat, and hundreds of researchers around the world are searching for ways to either prevent or treat the infection. For our experiments, Dr. Matt Peterson developed

small-molecule drugs that have shown, through immunofluorescence assays, anti-influenza activity in Madin-Darby Canine Kidney (MDCK) cells at pharmaceutical-grade concentrations. We show that one molecule in particular (J115) is especially effective with an EC₅₀ of $9.1 \pm 6 \mu\text{M}$ with an EC₅₀/CC₅₀ ratio of 10.99. We believe the primary target of these drugs to be vascular endothelial growth factor receptor, but studies show that pyrazolopyrimidine analogues, like our drugs, target multiple receptor tyrosine kinases. The results of our experiment suggest what others have hypothesized: that the sialic acid interaction that is traditionally held responsible for flu infection is insufficient for the virus to enter the cell and that influenza must utilize a yet-to-be-characterized secondary receptor interaction that promotes viral endocytosis.

POSTER

Topical Application of Wogonin Provides a Novel Treatment of Knee Osteoarthritis

Jacob Smith

Brigham Young University

Osteoarthritis (OA) is a degenerative joint disease characterized by joint pain, decreased functional mobility, and deformation of articular cartilage and consequentially diminishing quality of life. Wogonin (WG), a compound extracted from the Skullcap *Baicalensis* plant, has been shown to have anti-inflammatory effects on the Toll-like receptor 4 (TLR4) inflammatory pathway and antioxidant properties via Nrf2. We have shown that TLR4 is a major receptor for pain in OA. In our study, we examined the pain-reducing, anti-inflammatory, and chondro-protective effects of WG when applied as a topical cream. After destabilizing the menisci of mice to induce OA, we examined the severity and progression of OA with and without the topical application of WG. Using a running wheel to track mice activity, we found that mice with WG treatment were statistically more active than mice without WG treatment. OA progression analyzed using Modified Mankin and OARSI scoring showed a significant attenuation of OA severity among mice treated with WG as well as a decrease in cyst-like lesions at the chondro-osseous junction. Immunohistochemistry revealed a significant decrease in protein expression of TGF- β , HTRA1, MMP-13, NF- κ B, and hepcidin in treated mice showing a decrease in inflammation.

POSTER**The Effects of Environment and *Janthinobacterium lividum* on Chytrid Fungus****Elizabeth Bento***Dixie State University*

Despite being commonly found carrying a lethal flesh-eating chytrid fungus (*Batrachochytrium dendrobatidis*) that is known to suffocate most other amphibians, Zion Canyon tree frog (*Hyla arenicolor*) populations appear to be doing fine. It has been speculated in the past that the arid climate of Arizona and Utah, which these frogs call home, creates an unfavorable environment for chytrid proliferation. This is an especially promising hypothesis because these Canyon tree frogs have a very unique behavior when compared with most of their amphibian brethren: they sunbathe. This unique behavior seems to limit the ability of the fungus to spread among and survive on its hosts. Another factor may be at play in inhibiting chytrid growth: the presence of *Janthinobacterium lividum*, which is known to compete with and kill chytrid fungus. The present study seeks to determine whether the presence and activity of chytrid fungus on Zion Canyon tree frogs was hindered by either the environmental conditions in which the frogs were found, the presence of *Janthinobacterium lividum*, or a combination of the two factors. To do so, 50 DNA samples collected from the frogs were isolated using a 50-count QIAGEN DNA Isolation kit: DNeasy Blood and Tissue Kit, and then analyzed via PCR and gel electrophoresis for the presence of chytrid DNA. Afterwards, two separate agar gel cultures of chytrid were grown under the same environmental conditions: one of the cultures served as a control with only chytrid present, the other contained both chytrid and *Janthinobacterium*.

POSTER**The Effect of Urbanization on Genetic Diversity in Southern Utah Ant Populations****Johanna Garavito, Glade Shakespeare***Southern Utah University*

Genetic diversity is critical to a species' survival and the ability to adapt to changing environments. Conservation geneticists can use genetic

diversity for various species in a habitat to determine the overall health. With this information, conservation geneticists can prevent extinction and improve population viability. Ants (Formicidae) are tiny, invertebrate omnivores found all around the globe and are considered to be good indicators of ecosystem health. Our main goals were to characterize the population genetic structure and to investigate the effect of urbanization on genetic diversity in southern Utah. Samples were collected throughout Cedar City (Canyon Park, the Lake on the Hills, and Main Street) and outside of Cedar City at the SUU Mountain Center and Three Peaks Recreation Area. DNA was extracted with Qiagen's DNeasy Blood and Tissue Kit and amplified at 10 previously characterized microsatellite loci. Genetic diversity will be compared between urban (Cedar City locations), rural (SUU Mountain Center), and mixed use (Three Peaks Recreation Area) lands to see if urbanization negatively affects ant biodiversity, potentially decreasing ecosystem health.

POSTER

A Mycological Investigation of Darwin's Naturalization Hypothesis

Jonathan H Wasden, Geoffrey Zahn

Utah Valley University

Darwin's Naturalization Hypothesis is the idea that species more closely related to each other should be stronger competitors than more distantly related species. This hypothesis has been tested with different organisms throughout the years, particularly with plant groups, yielding mixed results. Our experiment is a preliminary step in testing this hypothesis with fungal species to see if the same patterns found in plants can be detected using this understudied group. We took three fungal isolates of varying phylogenetic relatedness, grew them in a fully factorial combination of competitive scenarios, and observed their growth rates. Species' identities were determined by Sanger sequencing of the ITS1-5.8S-ITS2 region of the ribosome encoding DNA sequence. *Mycosymbiocytes mycenaphila*, an ascomycete, outcompeted the two remaining isolates. However, due to *M. mycenaphila* being a fungal parasite and belonging to a different phylogenetic branch, these results are insufficient in either confirming or refuting Darwin's Hypothesis. Although this test is a poor approximation of natural conditions, the

results are an important first step to further study of Darwin's Naturalization Hypothesis in fungi.

POSTER

Examining the Role of Endophytes in Leaf Decomposition Microbial Fuel Cells for STEM Education

Garrett Matthews

Utah Valley University

Current research indicates a high level of reliance and interaction between plants and their fungal endophytes. These communities living within a plant's aboveground tissue can often serve as a beneficial disease modifier or provide other benefits. The majority of studies have investigated this plant-endophyte symbiosis from the perspective of the plant, rather than the fungus. It is more clear what benefit plants are receiving from fungi than what benefits fungi are receiving from inhabiting aboveground plant tissues. One current hypothesis for fungal benefits of endophytism is called latent decomposition. Simply put, saprophytic endophytes may benefit from a "head start" on decomposition of the plant's tissue when it dies by being present in advance. To test the latent decomposition hypothesis, we took samples from a single mulberry tree over time as leaves senesced. Leaf samples were finely cut and incubated on a modified mycological medium. Regions of fungal growth were isolated into pure cultures and subjected to Sanger DNA screening of the ITS rDNA. Fungal community structure from all leaf age groupings were compared, and there was no significant difference in community membership between healthy and senesced leaves. Our results were unable to disprove the latent decomposer hypothesis, suggesting that arrival priority on dead leaves may be a benefit to endophytic fungi.

POSTER

Perception Analysis of the Use of Indoor Plants and Their Benefits Among College Individuals

Jake Nymeyer, Misae Nomiya, Levi Neely, Nate Roundy, Hutch Rhees

Utah Valley University

Indoor plants are common household items across various demographics. Recent studies have shown that common household plants have a host of benefits. These range from medicinal plants, such as *Aloe vera*, that can aid healing and ease pain, to plants that can filter various impurities in the air. As more and more indoor plant benefits are discovered, it is worthwhile to investigate the perception of indoor plants among college individuals to analyze awareness and interest. To evaluate the perception of indoor plants among college individuals, a survey containing questions related to indoor plant perception and indoor plant benefit awareness will be conducted among individuals affiliated with Utah Valley University. Participants will be categorized based on age, gender, and race before statistical analysis will be used to organize and analyze data.

POSTER

Testing the Effectiveness of a Regional DNA Barcoding for Identification of Lichen-forming Fungi

Casey Jones

Brigham Young University

Current methods of identifying lichen forming fungal species by molecular means are limited by the generality of global databases. The efforts to create many of these global databases take place in Europe and are lacking in accurate and up-to-date DNA metabarcoding sequences for many lichen-forming fungi found locally in the Northwestern United States. We plan to create a regional database of 500 locally found lichen forming fungi and corresponding DNA metabarcoding sequences that would improve rates of proper identification of said lichen-forming fungi down to a species level.

POSTER

Changes in Xylem Anatomy During Fire Contribute to Post-Fire Mortality

Evelyn G. Linford, Jeffery M. Colbert, Jake E. Eiting, Grayson C. Hodge, Kristian R. Valles

Weber State University

Wildfire increases are putting forest populations at risk, both with initial deaths and with post-fire mortality. Populations at the periphery of wildfires are at risk for post-fire mortality, and two hypotheses are attempting to explain this phenomenon. The hypothesis attributing post-fire mortality to xylem conduit failure due to high temperatures has had an increase in support from various studies. The size and shape of the xylem conduit impacts its hydraulic vulnerability, which could be increased with changes to xylem conduit shape. This study examined anatomical changes to xylem conduits due to heating. Results showed a significant difference in conduit area in control and heating groups. This supports the hypothesis that high temperatures from wildfire cause changes in xylem anatomy, which contributes to post-fire mortality.

POSTER

Cleaning Up the Taxonomy of *Burkholderia* sensu lato Using Comparative Genomics

Matthew B. Crook, P. Estrada-de los Santos, M. Palmer, B. Chávez-Ramírez, C. Beukes, E.T. Steenkamp, L. Briscoe, N. Khan, M. Maluk, M. Lafos, E. Humm, M. Arabit, E. Gross, M.F. Simon, F. Bueno dos Reis Jr., W.B. Whitman, N. Shapiro, P.S. Poole, A.M. Hirsch, S.N. Venter, E.K. James

Weber State University

In recent years, three new genera have been segregated from the genus *Burkholderia*: *Paraburkholderia*, *Caballeronia*, and *Robbsia*. A phylogenetic comparison of these groups indicated that *Paraburkholderia* was paraphyletic and should be further split into three monophyletic groups. One of these groups includes the closely related species *P. rhizoxinica* and *P. endofungorum*, which are both symbionts of the fungal phytopathogen *Rhizopus microsporus*. We propose that this group be renamed *Mycetohabitans* gen. nov. The second group

comprises the *Mimosa*-nodulating bacterium *P. symbiotica*, the phytopathogen *P. cary*, and the soil bacteria '*B. dabaoshanensis*' and *P. soli*. We propose that this group be renamed *Trinickia* gen. nov. To confirm that these groups deserved generic status, we sequenced the genomes of 8 additional strains, including 7 type strains. The uniqueness of these proposed genera is supported by average nucleotide identity and average amino acid identity calculations and unique gains/losses of genomic content. We also examined the relationship of genes related to symbiosis (*nod* and *nif* genes) and pathogenesis (T3SS genes) relative to other symbiotic or pathogenic species of *Burkholderia* sensu lato.

POSTER

The Effect of Fish Stocking Pattern Changes on the Presence of Double-crested Cormorants at Suburban Ponds in Northern Utah

Austin White, Nicholas Padilla, Jantz Arbon, Kenzie Isaacson, Greg Mayer, Kelton Friedel

Weber State University

The double-crested cormorant (*Phalacrocorax auritus*) is a piscivorous bird populating a wide variety of aquatic habitats including urban fishing ponds. The behavior of cormorants has become increasingly important to wildlife managers in North America because of their predatory activity on stocked fish. Previous studies have looked at how cormorant numbers respond to the stocking of rainbow trout (*Oncorhynchus mykiss*) and channel catfish (*Ictalurus punctatus*) in small suburban ponds within northern Utah. These studies suggested that cormorant numbers increased following the stocking of rainbow trout. This prompted recommendations that were implemented with cooperation from the Utah Division of Wildlife Resources (DWR) in 2018. These recommendations included: stocking fewer rainbow trout more frequently, stocking rainbow trout that are larger in size, and stocking channel catfish in place of rainbow trout. Every morning during May and June of 2018, we censused the number of cormorants for 30 minutes at nine ponds, where we also measured other environmental factors. At selected ponds, fewer rainbow trout and more channel catfish were stocked compared with previous years. At one pond, Meadow Creek, the rainbow trout that were stocked were larger in size (~14 in). Another pond, Jensen Nature Park Pond, had rainbow trout stocked more frequently than in past years. These both showed a decrease in the average number of cormorants seen per day at their respective ponds.

This also showed an increase in the number of days where the ponds had no cormorants visit. These results were consistent with our hypothesis that decreasing the number of rainbow trout stocked, increasing the size of the rainbow trout stocked, and stocking channel catfish will reduce cormorant presence at these suburban ponds.

POSTER

Floral Color Preference and Conditioning in the Painted Lady Butterfly (*Vanessa cardui*)

Chyanne Smith, Heather O'Donnell

Weber State University

Painted lady butterflies (*Vanessa cardui*), like many other butterflies, are able to visually differentiate between colors. However, floral color conditioning and preference is poorly understood in this species and remains largely unexplored. We investigated the effects of floral conditioning in painted lady butterflies to synthetic white flowers to test trainability and color preference. We hypothesized that these butterflies, after a conditioning period, would be trained to show preference to white flowers, if all other floral factors were the same. Additionally, butterflies raised in a mixed flower color environment should show no preference toward any specific color. Results obtained suggest there is no significant color preference between butterflies conditioned solely on one color of flower versus butterflies conditioned to multiple colors of flowers. Future studies should be conducted that take into account conditioning period length, wing damage, and mating behaviors.

POSTER

Microbial Fuel Cells for STEM Education

Malack Mouhammad, Mason Burningham

Weber State University

STEM (Science, Technology, Engineering, and Mathematics) projects are an essential component in gaining a quality education. Microbial fuel cells (biobatteries) are an excellent informative topic for a STEM project because they are a simple and inexpensive way to provide insight into the STEM disciplines for students at all levels. They include aspects

from multiple science fields, for example, biology, physics, mathematics, and chemistry. As such, it is our hypothesis that experiments with biobatteries would educate and inspire students in STEM disciplines. Multiple construction methods of the batteries were examined, each with a variety of parameters. These parameters included electrode material, the source of organisms, and environmental factors. Each method provided an experimental approach that can be explored in the classroom. The most successful batteries were incubated at 25°C and were constructed in terracotta pots using soil as the electrolytic medium, terracotta clay-covered copper disks as the anode, and graphite paint covering the outer surface of the pot as the cathode. These batteries achieved an electrical potential reading of above 1 volt, compared with a 1.2-volt theoretical maximum, using this construction method. The target audience for this research is teachers. The biobattery is an easy and educational project to bring to the classroom, and due to the range of the parameters that can be investigated, would serve as a good introduction into the STEM fields. The presentation will also include background information to assist the teachers in explaining the many different concepts behind the biobattery.

POSTER

Optimization of Microbial Fuel Cells

Mason Burningham, Malack Mouhammad

Weber State University

Microbial fuel cells, or biobatteries, are systems that harness the capacity of some microorganisms to produce an electrical current as they undergo metabolism. These organisms are commonly found in soil samples rich in organic materials. These systems have a wide variety of potential uses, especially in environments that require a small, steady source of electrical power over long periods of time. These batteries are potentially inexpensive while remaining nontoxic, nonflammable, and environmentally friendly. The hypothesis was that simple biobatteries could be constructed that performed as well as more expensive, more complex systems described in the literature. We investigated the parameters under which biobatteries would produce the greatest electrical potential, comparing several factors. The batteries were produced from materials such as copper wire, terracotta pots, Mason jars, soil, graphite paint, and graphite or copper electrodes. Both the physical structure of the batteries and the environmental parameters were

investigated. Some physical traits that were tested included the location of the cathode on the terracotta pots, replacing the terracotta pots with Mason jars, the soil inside the pots, and the anode material. Environmental parameters included temperature and available moisture. Through this testing we were able to attain electrical potentials greater than 1000 mV, with some individual cases nearly reaching 1200 mV, which is the theoretical maximum voltage attainable from this system. This is notable because the highest reported potential we have found in the literature was roughly 700 mV. In terms of long-term viability, our pots remained functional over the course of over one year with little to no maintenance, although the electrical potential did decrease. Additional research into increasing output could be necessary for practical viability, which could include investigations into increased surface area of the electrodes and the behavior of the biobatteries when wired together in series or parallel.

POSTER

Predicting Catabolic Pathways in *Lactobacillus wasatchensis* Using Metabolic Modeling

Serena Seychelle Young, Matthew Domek, Michele Culumber, Craig Oberg

Weber State University

Lactobacillus wasatchensis, a nonstarter lactic acid bacteria (NSLAB), causes late gas production in aged Cheddar cheese, which results in splits in the cheese and package bloating. In this study, we attempted to identify which sugars or other carbon sources *Lb. wasatchensis* can use for growth and gas production in aging cheese. Previous studies showed galactose could be used by WDC04 to produce gas, but did not determine any carbon sources for late gas production in cheese when no galactose was present. Ultimately, we hope to define cheese compositions that either inhibit *Lb. wasatchensis* growth or prevent gas production. The *Lb. wasatchensis* WDC04 genome was exported from Genbank, then Knowledgebase (KBase) Predictive Biology's metabolic modeling was used to map the genes present for various metabolic pathways. Flux balance analysis showed *Lb. wasatchensis* contained a complete pentose phosphate pathway, while pathways for glycolysis, TCA, and galactose metabolism were incomplete. To confirm these predictions and to look for alternative carbon metabolic pathways, five strains of *Lb. wasatchensis* (CGL02, DH3, LD13, SH05, WDC04) were grown in

MRS broth supplemented with 7% oxyrase and 0.5% of either ribose, lactose, galactose, or N-acetylglucosamine (NAG). Growth was significant on ribose but negligible for lactose, galactose, and NAG, which confirmed the metabolic modeling data. KBase also indicated additional carbohydrates that might be used with the most promising being gluconate. It predicted that gluconate is converted to ribose-5-P using phosphogluconate dehydrogenase by a decarboxylating step, producing the CO₂ gas that causes splits in cheese. Further investigation of the metabolic modeling pathways, and metabolic confirmation, may provide a solution to late gas production by *Lb. wasatchensis* in aging cheese.

POSTER

Quantification and Analysis of Fecal Coliforms and the Seasonal Effects on their Relative Concentrations in Taylor Canyon Stream in Ogden, Utah

Matthew Mendoza

Weber State University

Fecal coliforms are facultative, anaerobic, gram-negative bacteria found ubiquitously within the digestive tract of warm-blooded mammals and the wastes they secrete. In mountain streams, coliforms are an indicator of potential contamination and the presence of other pathogens. The purpose of this research is to quantify the concentrations of fecal coliforms in Taylor Canyon Stream, in Ogden, Utah, and investigate possible correlations between coliform counts and precipitation events and seasonal changes. My hypothesis is that there will be a decrease in coliform population numbers as winter approaches and a snowpack starts to form. Conversely, I predict that there will be an associated increase in coliform concentrations as spring runoff increases, and if any form of a moderate precipitation event occurs. Concentrations of fecal coliforms will be measured once per week, by sampling the surface water of Taylor Canyon Stream in three 50-mL centrifuge tubes. Samples will be collected at three different locations. The water samples will be used to inoculate tryptic soy agar (TSA) plates, and fecal coliform and aerobic plate count petri-films for quantification. DNA will also be extracted from the water samples once per month for 16S rRNA gene microbiome sequencing. The microbiome data will give us genus-level resolution of the changes that are occurring during seasonal and weather events. Preliminary results indicate a relatively high total microbial count of

between 2,280 and 3,090 CFUs/mL measured on TSA. Aerobic plate counts on petri-film ranged from 170 to 230 CFUs/mL, while fecal coliform plate counts ranged from 0 to 30 CFUs/mL.

POSTER

Quantification of *Staphylococcus* Biofilm Clearance

Alma Kaneshiro, McKay Griffin, Jonathan Spencer, Daniel N. Clark

Weber State University

Antibiotic resistance is a problem of great concern in the medical community, with bacterial resistance to antibiotics increasing proportional to their use; antibiotic use has never been higher. *Staphylococcus aureus* bacteria such as methicillin-resistant *S. aureus* (MRSA) can cause fatal infections and are known for antibiotic resistance. The problems caused by this resistance are compounded when the infecting bacteria form a biofilm. Biofilms are thick sticky layers of bacteria and their secretions, and they are difficult for antibiotics to penetrate. Biofilm formation is common in hospital settings, such as on stents, catheters, and IV lines. Biofilms also make antibiotic treatment risky because of incomplete “killing” where the most resistant bacteria survive exposure. Interestingly, there is some evidence that bacteriophage (the viruses that infect bacteria) are able to break up biofilms, which may make them more susceptible to antibiotics. We chemically induced a *S. aureus* biofilm formation using chemicals that mimic a skin wound (4% glyoxyl, 4% formaldehyde, and 3% hydrogen peroxide). Using bacteriophage K (which specifically infects *S. aureus*), we inoculated the biofilm and observed clearance of the biofilm. Samples of cell pellets and liquid supernatant were collected by centrifugation, and DNA was extracted. Real-time PCR was used to quantify the levels of bacteriophage K replication in the biofilm, representing clearance of the bacteria, causing the biofilm to break apart. This research can be used to find more efficient ways to treat an infection caused by a *S. aureus* biofilm. Bacteriophage used in combination with antibiotics may be able to better clear a biofilm infection compared with antibiotics alone and may reduce the risk of antibiotic resistance by achieving more complete clearance of the infection.

POSTER

Surface Sampling Methods

Michael Tene, William Lorowitz

Weber State University

Students in Microbiological Procedures are required to perform independent projects designed to test a hypothesis, and many have chosen to compare surface contamination using RODAC plates. To expand their experiences, a lab exercise was designed to allow students to compare results using RODAC plates, swabs, and 3M Post-it Durable Filing Tabs (tape). The main hypothesis being tested was that students would gain experience with different surface testing methods and be able to compare them in terms of ease of use, accuracy, precision, and appropriate application. Pre- and post-tests were used to evaluate students' knowledge of these enumeration methods. Dilutions of *Staphylococcus aureus* were spread onto 3.2-cm² areas on aluminum foil. Plastic and glass surfaces were tested, but aluminum foil worked well. Comparisons revealed that RODAC plates had highest recoveries, typically less than 20%. While easiest to use, aseptic preparation of the plates could be challenging. Using the tape was awkward, but students felt it would become easier with practice. Swabs required a consistency in handling to reduce variance in colony counts. Overall, this exercise was deemed a success based on the pre- and post-test scores, lab reports, and use of swabs or tape for sampling in independent projects.

POSTER

Using *Aspergillus oryzae* to Enhance Umami Flavor in Beef

Immanuel Rodriguez, Samantha Brailsford

Weber State University

Koji is the Asian term for *Aspergillus oryzae*, which is used in many different Asian fermentations such as sake, miso, and soy sauce. *A. oryzae* is a fungus that is able to hydrolyze carbohydrates and proteins. In addition, it adds umami elements into the flavor profile of the fermented product. The hypothesis was that inoculating beef with *A. oryzae* and allowing it to grow would enhance the flavors and textures of the meat, tenderizing and adding elements of umami to the flavor profile of the beef. A literature review revealed methods of seasoning

beef with powdered Koji. When we tested this, it was agreed that the Koji improved the flavor of steak. The next question was to determine if allowing *A. oryzae* to grow on steaks would improve the beef further. To do this, we had to find methods to safely remove the indigenous microorganisms on the steak to prevent illness. After several trials it was determined an 8% salt or ½ strength soy sauce and vinegar (0.3% acetic acid) brine gave us the desired results. Steaks were marinated in the refrigerator for 24 hours. After rinsing, they were coated with powdered Koji and incubated in the refrigerator and 30°C for 2 days. The steaks were rinsed and cooked. Results indicated that all of the steaks inoculated with *A. oryzae* were more tender and had a stronger umami flavor. The steaks brined in soy were preferred over the 8% salt brine. Further experiments may include the fermentations of different meats using *A. oryzae* as well as fermenting at different temperatures and times.

POSTER

Interpreters and Interpretation: The Syncretic Crossroads Between Cultures

Rachel Montalvo, Brianna Kroll, Kyle Takke

Utah Valley University

Interpreters and their ability to cross cultural divides are always at the forefront of every cultural collision. Their valuable interpretation skills and accompanying multiculturalism often cost the interpreters their ability to fit into any existing group as they themselves have become a new syncretic entity. Interpreters such as La Malinche, Felipillo, Squanto, Sacagawea, Jean Herbert, and David Akira Itami have all been at the forefront of turning points in history, although in some cases their stories have been told by an unsympathetic winner, or their contributions almost entirely forgotten. In today's global economy, the ever-increasing demand for valuable interpretation services has grown exponentially, helping to bridge language barriers and provide vital cultural understanding. In our presentation, we will examine the contributions of these pivotal interpreters, how their stories have evolved during and after their lifetimes, and how interpreters continue to pave the way for a new syncretic world.

POSTER

Analysis of Fluoride in Dental Products by Flow Injection Analysis

Kacey Green, Peter Iles, Sarah Moore, Kacey Green, Creed Anderson, Jacob Hughes, Chase Sorensen, Patricia Beslagic, Luther Giddings, Ron Valcarce

Salt Lake Community College

According to the Salt Lake Valley Health Department, the optimal level of fluoride is 0.7 to 1.2 ppm in drinking water. In 2003, the State of Utah started adding fluoride to tap water. At present, the state has about 50% of the population receiving fluoride treated water with the aim of reaching the 1-ppm fluoride level. The acidity of many foods and drinks leads to tooth decay, and dental products claim to prevent decay via cleaning and fluoride. This study examined the fluoride content in fluoride dental varnish and tablets containing fluoride. Products containing fluoro-phosphate require strong alkaline hydrolysis prior to mixing with TISAB 11 and injection into a flow injection analysis system employing an ion-selective electrode as detector. The values found in dental products are reported and compared with label claims.

POSTER

The \$6M Special Education Teacher: Better, Faster, Stronger?

David R. Byrd

Weber State University

Students with special needs represent a significantly large part of the education population; therefore, all types of teachers will have these students in their classrooms during their careers. When students with disabilities receive services in the general education classroom, this is often referred to as inclusion, or serving students with various levels of abilities or disabilities in the general education classroom with in-class support, suggesting a major focus on collaboration. Although a universal definition of collaboration has been difficult, collaboration in education suggests a shift from a teacher-centered mode of instruction to one that involves new kinds of relationships, including (among others) teacher-teacher and teacher-specialist interactions, team models, and school-

family relationships, as well as interactions among learners. Research indicates that collaborative efforts within the school context are beneficial, especially for teaching and learning quality. Collaboration helps create moral support, as teachers respond to problems together. In these collaborative efforts, each set of educators brings different ideas and strengths to the table. This exploratory study looks at surveys and interviews conducted with mainstream and special education teachers and school administrators to describe what it takes to become an excellent special education teacher in the inclusive situation. Using constant comparative methodology, the researcher examined 50 surveys and interviews of teachers across the US. The guiding principle was to determine what kinds of descriptors the participants used to express their views. The results indicate that specific traits over educational experiences were most frequently mentioned to describe the excellent special education teacher. The findings are applicable to both pre- and in-service teaching situations.

POSTER

Identification of Pharmaceuticals in Utah's Jordan River

Jacob Hughes, Christopher Peak, Ibtihaj AL-Nidawi, Brendan Schnopp

Salt Lake Community College

The Jordan River is a principle source of ground water along Utah's Wasatch Front. Treated waste water is discharged by multiple facilities into its source, Utah Lake, and into the river itself at several locations before it empties into the Great Salt Lake. Detailed analysis of selected pharmaceuticals present in the river's water is sparse. The presence of pharmaceutical products in the river may result from human and animal excretion directly into the watershed, into sewage and septic systems that feed into the river, or by the disposal of excess pharmaceuticals into these systems. This study intends to conduct analyses of Jordan River water at various locations between Utah Lake and the Great Salt Lake. LC-MS will be used to analyze and identify selected pharmaceutical products present in the river water using EPA method 1694, modified to suit available instrumentation and resources. Identification of common pharmaceuticals in the water may lead to better methods for their removal and improve public awareness of the potential problems these compounds present as pollutants.

POSTER

Comparative analysis of Rose Volatiles in Essential Oils via GC-MS

Jie Mei Chong, Jessel Meza De La Cruz, Mary Alvarez

Salt Lake Community College

Roses cultivated for commercial perfume production include only a few varieties bred for the purpose. However, many rose varieties are cultivated and sold for different purposes, including color, scent, cold hardiness, and disease resistance. Individuals interested in making rose-scented perfumes or other products at home are more likely to have access to and use rose varieties available locally, including floral shops and garden varieties. In this study, rose petals of different locally available varieties were extracted and analyzed via GC-MS for plant volatiles. Volatile compounds were compared against those present in commercial rose essential oils.

POSTER

9-BBN Catalyzed Hydroboration of Enynes

Marcus Mifflin, Nathan Werner

Southern Utah University

The importance of organoboronic ester derivatives in modern organic synthesis is largely attributable to their versatility in forming C-C bonds in the Suzuki-Miyaura cross-coupling reaction. The goal of this research was to synthesize a pinacolborane-substituted diene by the 9-BBN catalyzed hydroboration of (E)-but-1-en-3-yn-1-ylbenzene with pinacolborane. This hydroboration reaction is of particular interest because of the two potentially reactive sites (i.e., an alkene and alkyne). Therefore, the opportunity to develop a novel and selective method for the preparation of this class of compounds exists. In addition, the product is of high synthetic utility in the reactions of dienes (Diels-Alder cycloaddition) and boronic esters (Suzuki-Miyaura cross-coupling).

POSTER**Caffeine-Derived Ligands in the Sonogashira Cross-Coupling Reaction****Garett L. Ruesch, Nathan S. Werner***Southern Utah University*

Organic ligands are essential in the selective metal-catalyzed synthesis of compounds for medicinal and materials chemistry. The Lewis basic ligand binds to and affects the reactivity of the metal. Indeed, the unique structure of each new ligand can change the efficacy and selectivity of the overall catalyst. The objective of this research was the preparation of caffeine-derived ligands and the study of their effect on the Sonogashira cross-coupling reaction. Our goals for this project were to develop catalysts with increased specificity, efficacy, and stability. Catalysts were produced in situ by the combination of copper and/or palladium, the caffeine derivative, and a base. The effect of the caffeine-derived ligands on the Sonogashira reaction was determined by gas chromatographic analysis of crude reaction aliquots and isolation of major reaction products.

POSTER**Demonstration in Classroom, Effect on Learning****Hussein Samha, Jessie Byers, Said Bahi***Southern Utah University*

Demonstrations have become widely used and respected instructional tool in chemistry and other sciences because they provide real examples of everyday life and help students visualize and apply concepts. This presentation discusses the results of a study that evaluates the effectiveness of laboratory demonstrations versus self-directed student experiments in an introductory chemistry course. Final examination scores across 12 semesters for each method of teaching were compared statistically. Scores on the demonstration portion of the examination were found to be significantly higher on average than the scores on the experiment portion of the examination. This suggests that demonstration could be a more effective method of helping students retain information than self-directed experiment. Additionally, students from selected classes were surveyed about their retention and comprehension rates

from the two teaching methods. It was found from the survey that students, in general, retain information better from demonstration.

POSTER

Construction and Development of Dielectric Mie Resonance-Based Metamaterials

Spencer Nicholls, Shane Howard, DrBrandon Burnett

Weber State University

With the increase in demand of solar and other thermal radiative energy conversion technologies, the need for optimization of thermophotovoltaic (TPV) cells is crucial. The current maximum efficiency from TPV technology is typically 1–10%. A significant portion of the losses in TPV cells is due to the spectral mismatch of the TPV material bandgap and the radiation source energy. It has been theorized that a group of materials called Mie resonance-based metamaterials can help with TPV technology by upconverting low-energy light into the bandgap energy range. Currently, actual examples of these types of materials are scarce. We present the construction and optimization of a group of Mie resonance-based metamaterials for the use in TPV cells. Successful fabrication of a metamaterial capable of upconverting low-energy light at the bandgap of TPV materials can significantly increase the performance of TPV devices.

POSTER

Quantitative NMR Determination of Fluorine in Toothpastes

Thomas Ericson, Edward Walker, Barry Lloyd

Weber State University

Toothpastes containing fluoride to help prevent cavities are regulated as “over-the-counter” drug products. In the USA, sodium fluoride (NaF) is the fluoride source most often added to supply fluoride. In Europe and other countries, sodium monofluorophosphate (MFP) is active ingredient in toothpastes. Fluoride is most often measured by diluting the toothpaste in deionized water and then tested with a fluoride-specific ion electrode (SIE). This works well for ionic fluoride as in NaF, but fluorine in MFP

is covalently bound and does not form fluoride ions, thus rendering the SIE useless unless the MFP is first subjected to extensive acid hydrolysis. NMR is particularly useful in analysis of pharmaceutical products containing fluorine. We have applied NMR to quantitatively determine the fluorine content in toothpastes for both NaF and MRF active ingredients simultaneously, since fluorine absorbance frequencies shift depending on its molecular environment. Furthermore, whole toothpaste is analyzed directly, avoiding sample preparation such as dilution or hydrolysis.

POSTER

Impact of Massage Chair Use on Perceived Stress and Pain Levels and Physiological Heart and Blood Pressure Rates in Adults

Michael Olpin, Shirley Dawson, Ryan Davis

Weber State University

The purpose of this study was to explore the effects that massage chairs have on the stress levels, pain levels, heart, and blood pressure rate of visitors at a university stress relief center in the mountain western United States. From February 2015 to April 2017, data was gathered from over 5,000 visitors using massage chairs at a university stress relief center. The results were analyzed using quantitative causal comparative post-hoc methods. Significant lowering of blood pressure, heart rates, perceived pain, and perceived stress levels occurred after using massage chairs for all visitors regardless of age, gender, or university role.

POSTER

Look Up! Researching the Effects of Technoference on Parent-Child Relationships

Amanda Schill, Amanda King-Robinson, Daniel Ruesch, C. Ryan Dunn

Weber State University

Technology has become a significant part of most people's daily lives. The Pew Research Center (2018) reports that 95% of Americans own some sort of cell phone, and of those, 77% owned a smartphone. Because

of the increasing impact technology has on relationships, Stockdale, Coyne, and Padilla-Walker (2018) have coined the term “technoferece” to describe the interference, intrusions, and disruptions to a relationship caused by the use of media and technology. Previous research explores parental distraction from technology, negative impacts of technology use, and positive impacts of technology use. Parent/child relationships have been found to be related to young adult’s life satisfaction (Levin & Currie, 2010). Baram (2015) found that media use leads to fragmented and chaotic care because of the disruptions devices caused. When these interruptions add up over time, it can lead to long-lasting consequences and increase the likelihood of risky behaviors and depression in adolescence and young adults. The current study was framed in Bronfenbrenner’s (1979) ecological theory of human development and aims to investigate how parent’s screen time during adolescence affects the parent–child relationship as well as life satisfaction for young adults (ages 18–25 years). To assess these relationships, Weber State University students from the Weber-Davis area of northern Utah were recruited using email, social media, and advertisement posters on campus to take part in an online survey tapping their experiences with parent technology use, life satisfaction, and other socio-demographic factors. The hypothesis of the research is that there will be a reported relationship between technoferece and the quality of the parent–child relationship. The secondary hypothesis is that there will be a negative correlation between the amount of time parents spend using technology during adolescent years and the quality of the parent–child relationship reported by young adults, ages 18–25 years.

SOCIAL SCIENCE

“Black, Brown, and White”: Oppositional Performance in American Blues and R&B Music

Theresa Martinez

University of Utah

To say that American blues music was born from the horrors of slavery and the legacy of Jim Crow oppression of African Americans would not be putting too fine a point on the matter. Blues was a direct descendant of the field hollers of African slaves and of the experiences of African Americans as they navigated a Post-Reconstruction South. Rhythm and blues (R&B) was, by contrast, a peppier urban music derived from southern blues that followed the migration of Blacks from the South to

the North in the early 20th century. R&B, while less of a gritty, country sound, offered no less of a reflection on Jim Crow than its predecessor, although it tended to be more straightforward in its depiction of race, class, and gender realities. This paper is an exploration of these quintessential American musical genres through a conceptual framework that builds on the dramaturgical approach in sociology as well as oppositional culture and resistance theories performance as resistance or oppositional performance. Through a thematic analysis of the lyrics of selected American blues and R&B artists, we will reveal a wealth of oppositional performance.

SOCIAL SCIENCE

Non-Ideal Theory and Genetic Research for Indigenous Populations

Rachel Robison-Greene

Utah State University

In 2002, the Navajo Nation placed a moratorium on genetic research within its territorial jurisdiction. Among the motivations were concerns about the misuse of data and the potential for privacy violations. Many members of the Navajo Nation were opposed to the moratorium, primarily because of the medical benefits of genetic testing. Recently, the Navajo Nation announced that they are considering lifting the moratorium. Concerns about data misuse are not misguided. The Havasupai Tribe encountered just such a situation recently. In 1989, the Tribe entered into a research arrangement with Arizona State University. The Havasupai experience higher than average rates of type II diabetes. The research agreement involved an investigation into a possible genetic link to the disease. The search for such a link was unsuccessful. The genetic material was then used for purposes that were never agreed to by the research participants. The samples were used to study migration, inbreeding, and schizophrenia. A lawsuit was later settled out of court. Use of genetic material for these purposes is far from innocuous. The mere engagement in these research projects, regardless of the results, has the potential to further stigmatize and exploit Native People. Policy with respect to genetic testing of indigenous populations must navigate a wide range of political and cultural realities. Ideal theory has little to offer. This paper will explore approaches to this challenge with a non-ideal theoretical ethical framework in mind.

SOCIAL SCIENCE

Does Unemployment Affect Presidential Elections? It Depends Where You Look

Pook Carson, James P. Gander

Salt Lake Community College

This paper examines the relationship between unemployment rates and U.S. presidential election outcomes over the time period 2000–2016. We use a Bayesian methodology to uncover elasticities between unemployment and both the popular vote and Electoral College vote at the state level. The models are estimated using Hamiltonian Markov Chain Monte Carlo (MCMC) both with and without shrinkage. The key hypothesis that economic conditions as given by unemployment rates can explain electoral voting outcomes is supported, but only for select states. Unemployment in most states has no effect on election outcomes. The popular vote is more responsive to unemployment, although elasticities vary significantly across states and parties. Higher unemployment increases voter turnout, with Blue States voting more Democratic and (most) Red States actually voting more Republican. However, this retrenchment in Red States has no effect on election outcomes.

SOCIAL SCIENCE

The Silent Military Rape Epidemic

Mikelle Wrobel

Salt Lake Community College

Nathan Galbreath, Deputy Director of the Sexual Assault Prevention and Response Office, claimed that it was difficult to determine what caused the increase of sexual assaults regarding the Army (8.4%), Air Force (9.2%), Navy (9.3%), and Marine Corps (14.7%). Do the reported sexual assaults statistics accurately reflect the experience of military personnel? To determine whether this was the case, I conducted field research through anonymous surveys and interviews. I also analyzed existing statistics that have already been reported. With conflicting statistics being found, it was concluded that further research would be needed to determine whether or not there are more assaults and rapes being reported, like the D.O.D. stated, and fewer assaults and rapes actually taking place.

SOCIAL SCIENCE

Understanding Us

Jennifer Salazar, Blerona Asllani, Matt Roberts, Max Weaver, Dan Poole

Salt Lake Community College

Salt Lake Community College student researchers collaborated with Understanding Us, a local nonprofit organization, to collect demographic information among people experiencing homelessness in downtown Salt Lake City. This organization currently provides several programs, including a Tai Chi program at the downtown library and Road Home homeless shelter. Student researchers have collected preliminary demographic survey data to help the organization better understand the population they are serving to best meet the needs of participants. This information will help to measure program efficacy, educate the broader community about homelessness, and help to provide data that can be used to further Understanding Us programming.

SOCIAL SCIENCE

To Protect a Scumbag: Or, What Is it About Larry Flynt that Provokes Such Cowardice in the Mainstream Media?

Thomas C. Terry

Utah State University

Politics makes strange bedfellows, but the mainstream media simply refuses to climb under the constitutional covers with Larry Flynt as he repeatedly defends First Amendment principles. Constitutional controversy seems to be as attractive to Larry Flynt as the women with whom he surrounds himself. In two decades, he has launched multiple First Amendment assaults in the courts, one making it to the Supreme Court and winning and one rejected by the high court without being considered. Larry Flynt is an unlikely hero for journalists. And a difficult one to like and defend. Some disassociate themselves from him while identifying with his stances. He is frequently crude, always outspoken, and unrepentantly hedonistic. Yet some believe his portrait should hang next to that of John Peter Zenger, I.F. Stone, Thomas Jefferson, James Madison, and Edward R. Murrow in any shrine to the champions of a

free press. This is not because he necessarily does good journalism or is tasteful in what he does. That is certainly open to much debate. No, it is because he has the strength of character and commitment to defend the First Amendment when the “usual suspects” balk. “If the First Amendment will protect a scumbag like me,” Larry Flynt observed, “it will protect all of you.” So, why has the mainstream press in recent years failed to support both Flynt and the ideals that have motivated American journalists for well over two centuries? This article will visit several famous free press challenges, such as the Pentagon Papers, *New York Times v. Sullivan*, and Watergate, when the media did rise to the constitutional challenge. It will look at restrictions on news helicopters post-September 11 and constitutional access to the battlefield that in the past would have prompted legal action by the media.

SOCIAL SCIENCE

Survey of First Experience of Sexual Intercourse: Revisited

Mackenzie Hughes, CoCo James, Spencer Blake

Salt Lake Community College

One’s first experience of sexual intercourse is widely recognized as an important milestone. For most, heavy emotions surround coital debut. Hence, the topic is often discussed in a research setting. In a 1988 survey, Dee Stroub asked students from several colleges across the Intermountain West to reflect on their first sexual experiences (Stroub, 1988). Stroub focused primarily on attitudinal differences in respondents based on sex. He found that women were much more likely than men to report negative reflections of their coital debut (e.g., fewer orgasms, stronger feelings of remorse or misgivings). CoCo James, Richard Cunningham, and Spencer H. Blake later replicated Stroub’s survey at Salt Lake Community College (SLCC) and compared their findings (James, Cunningham, & Blake, 2009). While women still reported more negative reflections on their feelings after sexual debut, the gap between men and women’s answers shrank. They also found an increase in the use of contraception, the most common method being condoms. These findings may be attributed to a recent normalization of sex positivity for women. In 2018, researchers distributed a similar survey again to more than 500 SLCC students. The responses expressed attitudinal changes in the Intermountain West over time. The survey’s language was updated to reflect current research standards. By stepping outside of the gender

binary and adding more LGBTQ-inclusive questions, the researchers created a more thorough and inclusive study. The survey also displayed differences in sexual attitudes based on the religiosity of respondents. Collectively, the survey showed that attitudes in the Intermountain West are changing and becoming more normative in relation to national data.

SOCIAL SCIENCE

Plea Bargaining—Is the World Following in our Footsteps in Over-using Plea Bargains?

Rachel Watson

Weber State University

Plea bargaining has been around for centuries in the United States. Even looking back to 1930, we can see that almost 90% of cases ended in plea bargains. Although the percentage back then was extremely high, courts and lawyers were still relatively weary and reluctant regarding plea bargaining. It wasn't until 1970 with the case *Brady v. United States* that plea bargaining established legal grounding. Today, in the United States, around 94% of all cases are plea bargained. There are many reasons and justifications for why plea bargaining happens so much. In the United States, while most of the reason and justifications are valid, many would argue plea bargaining is over-used. This presentation aims to explore the value and limitations of plea bargaining in the United States by comparing it with plea bargaining in other countries, specifically Francophone countries, such as France and Canada focusing on the province of Québec. Previously, both these other countries have been deterred from using plea bargains because of the power it gives the public prosecutor. Does plea bargaining give public prosecutors too much power? This question will be addressed by means of cultural comparison. The specific case of *Brady v. United States* where plea bargaining got legal standing will be examined, as well as how it has changed throughout the years in the United States. We will then consider why France and Canada have been so hesitant to implement plea bargaining into their justice systems. Recently, Canada and France have both implemented the American-style plea bargaining into their courts, although not yet to the same extent as in the U.S. We will look at examples of recent cases where they have implemented plea bargains, how they turned out, and how it affected their court systems.

SOCIAL SCIENCE

Reviewing the Beck Depression Inventory on its Psychometric Properties

Bryan J. Dalley, Jordon K. Ciriako, Kylie Zimmerman, Russell T. Warne, Kayla Stubbs

Utah Valley University

The Beck Depression Inventory (BDI) is one of the most popular instruments in clinical practice and research. Practitioners often use the BDI to screen for depression and to assess the severity of depressive symptoms. Researchers often use the BDI to study depression in various populations, such as college students, adolescents, and substance abusers. In this test review, we explored the literature on the BDI's score reliability and the validity of its uses. Strengths of the BDI include high internal consistency and test-retest reliability, strong content validity, easy and cheap administration methods, and considerable convergent validity evidence. Weaknesses include high face validity (which allows clients to "fake" scores) and unrepresentative norm samples. There are gaps in the literature in regards to criterion-related and divergent validity evidence and test bias among people aged 60 to 80 years. Until researchers further investigate these areas, we cannot make a full judgment of the BDI. However, for now, the BDI seems to be an appropriate instrument for the screening and researching of depression.

SOCIAL SCIENCE

Mixed Methods Evaluation of Formal Mentoring: Journey UP for Aging Out of Foster Care

Barrett Bonella, Keeley Beirwolf, Lisa Coleman, Camille Sterger, Katharina Pulli, Clarissa Anguiano, Keirsten Barton

Weber State University

There are 415,000 children in foster care in the United States. Many of those children will turn 18 before being adopted, meaning they will "age out" and essentially be on their own as adults. We wanted to see if formal mentoring programs improved outcomes for those aging out of foster care, and the Journey Up Mentorship Program in Salt Lake City offered such a program. Forty-nine youth who had aged out of foster care with the help of mentors were surveyed and found they scored significantly

higher in their ability to get jobs and were less at risk for addiction, homelessness, and incarceration compared with data from the National Youth in Transition for Utah. Fifteen additional youth were interviewed in focus groups to explore the results further. Qualitative data showed participants were not at less risk given their stories and benefited from mentors' consistency, positive role modeling, and lessons on being an adult. This is consistent with other studies on the topic of mentoring, but should be expanded into more specified comparative studies and use larger sample sizes.

SOCIAL SCIENCE

The Color of Justice: Predictors of Support for Black & Blue Criminal Justice Movements

R.C. Morris

Weber State University

In the contemporary politicized climate of criminal justice, the term “identity politics” acts as a catch-all describing various divisions both within and without professional criminal justice. Despite its popularity, the term “identity politics” gets thrown around with little to no conceptual grounding, fostering confusion and miscommunication. Scholars have been working to establish value orientations as an important source of motivation driving the types of behaviors motivating people to participate in social movements where identity politics and criminal justice policy/procedure intersect. Examples where these intersections are prominent include politically charged movements such as #blacklivesmatter and #bluelivesmatter. Research finds that values oriented toward conformity motivate actors to support more punitive social policy. This study extends these findings to test how value domains of conformity and punitivity contribute to support for Blue or Black lives, net of other important factors contributing to social movement participation such as political identity, race, class, and gender. Results indicate that conformity value identities as well as punitivity positively correlate with support for Blue Lives Matter, while negatively correlating with support for Black Lives Matter. Conversely, results indicate that benevolent value identities positively correlate with support for Black Lives Matter, while negatively correlating with support for Blue Lives Matter. Implications for defining “identity politics” as a value-driven component of a person’s identity get discussed, as well as

how support or non-support of criminal justice-related movements gets influenced by value-laden identity politics.