

The Journal of the  
**Utah Academy of  
Sciences, Arts, & Letters**  
Volume 91 • 2014

**Includes selected and refereed articles from the  
2014 Annual Conference  
held at  
Dixie State University  
April 11, 2014**

**Editor**  
Kristin L. Kraus

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ISBN-13: 978-0-9815501-8-3

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## 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](http://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 ten and twenty double-spaced pages. Detailed instructions to authors are available at [http://www.utahacademy.org/Instructions\\_for\\_Authors.pdf](http://www.utahacademy.org/Instructions_for_Authors.pdf).

Among the bibliographic services listing at Bowker Serials Bibliographies and The Standard Periodical Direction. Indexing and abstracting services that cite articles in the journal include Arts and Humanities Citation Index, Biosciences Information Services, Current Geographical Publication, Chemical Abstracts, Mathematical Reviews, MLA Biography, Sociological Abstracts, Excerpta Botanica, Social Planning, Policy and Development Abstracts, Language and Language Behavior Abstracts, Index to Scientific Technical Proceedings, and Index to Social Sciences, and Humanities Proceedings.



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Sciences, Arts, & Letters—2014**

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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.*

### **Dr. Joyce Kinhead**

*Professor of English  
Utah State University*

Dr. Joyce Kinhead is Professor of English at Utah State University, where she joined its faculty in 1982. She served as Associate Vice President for Research at Utah State University, 2000-2011. In her roles as Acting Dean and Associate Dean of the College of Humanities, Arts and Social Sciences, she developed a number of programs over her ten-year tenure in the college: Writing Fellows, Undergraduate Teaching Fellows, and Faculty Development in Teaching, Research, and Outreach. She has also served as director of the Writing Program and the Writing Center. In 1999-2000, she was an American Council on Education Fellow with an appointment at the University of California-Davis and Keimyung University in Taegu, South Korea. Her international work includes being a Fulbright Scholar at the University of Stockholm (1987) and for the Ministry of Education in Cyprus (1996).

She is the author or editor of a number of books: *Farm: A Multimodal Reader* (2014); *Undergraduate Research Offices & Programs* (2012); *Advancing Undergraduate Research: Marketing, Communications, and Fund-raising* (2011); *Undergraduate Research in English Studies* with Laurie Grobman (2010); *Valuing and Supporting Undergraduate Research* (2003); *A Schoolmarm All My Life: Personal Narratives from Early Utah*; Houghton-Mifflin *English* (4 volumes); *Writing Centers in Context*; *Literary Utah: A Bibliographic Guide*; *Collaborative Writing: Essays in Process*; *The Center Will Hold*. With Jeanette Harris, she edited *The Writing Center Journal* for six years, and she is a founding board member of the National Writing Centers Association. In addition to 12 books, 10 book chapters, some 50 articles, reviews, and encyclopedia entries, and over 100 professional presentations, she is at work on *Researching Writing: An Introduction to Research Methods in Writing Studies*.

## ACADEMY FELLOW 2014

**David R. Keller, Ph.D.**

*Utah Valley University*

After receiving a double-major baccalaureate degree in English and Philosophy from Franklin & Marshall College and a masters degree in Philosophy from Boston College, David earned a doctorate in Philosophy at the University of Georgia. His dissertation, written under the direction of Frederick Ferré, addressed environmental philosophy. At Georgia, he also completed the interdisciplinary graduate Environmental Ethics Certificate Program.

Arriving at UVU fall semester 1996, Dr. Keller has held the rank of Assistant, Associate, and Professor of Philosophy. David has taught in the Philosophy, Humanities, Integrated Studies, and Environmental Studies programs. David became Director of the Center for the Study of Ethics in 1999. He served as co-founder and Executive Committee member of the Society for Ethics Across the Curriculum from October 2000 to December 2005. David served as Acting Interim Dean for the School of Humanities, Arts, and Social Sciences from January through May 2002, Assistant Vice President for Academics from January 2003 to August 2004, Administrator and Chair of the Institutional Review Board from June 2003 to August 2006, and President of the UVU Chapter of the American Association of University Professors from September 2007 to August 2009.

David received a Merit Award from the Utah Humanities Council for his Religion and Views of Nature Conference in 1998. David was named Faculty Senate Teacher of the Year during the 1999-2000 academic year for the School of Humanities, Arts, and Social Sciences, and was honored by the UVU Board of Trustees with an Award of Excellence in 2001. In February 2001, the Ethics Across the Curriculum program earned UVU the first place honor of the prestigious Theodore M. Hesburgh Award for Faculty development to Enhance Undergraduate Teaching and Learning. David received Dean's Faculty Scholarship Awards in 2001 and 2010 for the publication of *The Philosophy of Ecology* and "A Brief Overview of Basic Ethical Theory" (in *Ethics in Action*) respectively.

**O.C. TANNER PANEL**

**THE VALUE OF MY FIELD: AN INTERDISCIPLINARY  
DISCUSSION**

**Daniel Fairbanks, M.S., Ph.D., Gregory Prince, D.D.S.,  
Ph.D., and Matthew Wickman, M.A., Ph.D.**

**Daniel Fairbanks, M.S., Ph.D.**

*Dean of Science & Health*

*Utah Valley University*

Daniel Fairbanks (Arts) is an accomplished scientist, artist, author, and teacher. He currently is Dean of Science & Health at Utah Valley University, and has been a professor at the University of Massachusetts–Amherst, Southern Virginia University, Brigham Young University, and Fulbright Professor at the Universidade Estadual de Londrina in Brazil. He is a geneticist with a wide breadth of expertise in evolutionary genetics, international scientific development, science education, and the history of genetics. His most recent book is *Evolving: The Human Effect and Why It Matters*, published in 2012 by Prometheus Books. Other books include *Ending the MendelFisher Controversy* (University of Pittsburgh Press, with A. Franklin, A.W.F. Edwards, D.L. Hartl, and T. Seidenfeld), *Relics of Eden: The Powerful Evidence of Evolution in Human DNA* (Prometheus Books), and *Genetics: The Continuity of Life* (Brooks/ColeWadsworth, with W.R. Andersen). His research articles have appeared in a wide variety of journals, among them *Genetics*, *BMC Evolutionary Biology*, *Genome*, *Theoretical and Applied Genetics*, *Evolution: Education and Outreach*, and *Science Education*. He is among the leading authorities on the history of genetics, specializing on the legacies connecting Gregor Mendel, Charles Darwin, and Ronald Fisher.

## **Gregory Prince, D.D.S., Ph.D.**

### *Virion Systems, Inc.*

Gregory A. Prince (Biology/Science) was born and reared in Los Angeles, California. He attended Dixie College and UCLA, earning degrees in dentistry and pathology. The focus of his scientific research, spanning four decades, was respiratory syncytial virus (RSV), the primary cause of infant pneumonia worldwide. Over a period of 15 years at the National Institutes of Health, he and his coworkers developed the thesis that RSV disease could be prevented by administering antiviral antibodies to high-risk infants. He cofounded Virion Systems, Inc., and worked with MedImmune, Inc., to conduct clinical trials that resulted in the licensure by the U.S. Food and Drug Administration of RespiGam® (1996) and Synagis® (1998) for the prevention of RSV pneumonia in high-risk infants. Synagis is the first and only monoclonal antibody licensed for use against any infectious agent. He has published over 150 scientific papers. In addition to his career in science, he has developed an avocation as a historian of Mormonism, publishing many articles and two books, *Power From on High: The Development of Mormon Priesthood* (1995), and *David O. McKay and the Rise of Modern Mormonism* (2005). He and his wife, JaLynn Rasmussen Prince, are the parents of three children.

**Matthew Wickman, M.A., Ph.D.**

*Director of BYU Humanities Center  
Brigham Young University*

Matthew Wickman (Humanities) completed his PhD at UCLA in 2000 and began working that year at BYU as a specialist in eighteenth-century British literature. His interests multiply: currently, they include Scottish literary studies of the eighteenth century and after, literary theory, intellectual history, Romanticism, Modernism, interdisciplinary humanities (involving mathematics, law, the sciences, etc.), and more. For three years (2009-2012) he held a joint appointment between BYU and the University of Aberdeen in Scotland, where he was Senior Lecturer of Scottish Literature. He returned full-time to BYU in 2012 and assumed his current position as founding director of the new BYU Humanities Center.

He is currently at work on two book-length projects. One nearing completion, "After Euclid, Before Scott," takes intersections between literature and geometry as the basis for a reconsideration of literary form and the legacy of the Scottish Enlightenment. The other, "Tartan Noir, or, Hard-Boiled Heidegger" inverts the normative critical relationship between literature and theory, taking Scottish crime fiction as an explanatory genre for modern ontology rather than the converse. Indeed, this body of fiction makes Heideggerian and other ontologies seem like a reflex of genre fiction in their conventionality, even their kitsch, making for a strange variation on the idea of present-day posthumanism.

## **JOHN & OLGA GARDNER PRIZE**

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

### **Dr. C. Arden Pope III**

*Mary Lou Fulton Professor of Economics  
Brigham Young University*

Dr. C. Arden Pope, III, is currently the Mary Lou Fulton Professor of Economics at Brigham Young University. He grew up on a farm in Idaho, graduated from Brigham Young University in 1978, received his MS and PhD degrees from Iowa State University in 1981. He was an assistant professor at Texas A&M University before joining the faculty at Brigham Young University in 1984. His training was in economics and statistics and his early research publications related primarily to agriculture, natural resources, and environmental economics.

In the late 1980s, Dr. Pope began conducting cross-disciplinary research in environmental economics and air pollution epidemiology that resulted in several pioneering studies on the health effects and costs of air pollution. In 1992/93 he was a Post-Doctoral Fellow and Visiting Scientist at the Harvard School of Public Health. He has continued to collaborate with Harvard colleagues as well as colleagues from the University of Utah, American Cancer Society, University of Ottawa, University of California Berkeley, New York University, Brigham Young University, and elsewhere. He has conducted and collaborated on a series of seminal studies of human health effects of air pollution. These studies have been published in premier medical, public health, environmental science and related journals and have been heavily cited.

Dr. Pope has played prominent roles in reviewing and interpreting the literature and is one of the world's renowned experts on the health effects of air pollution. His research findings have influenced environmental and public health policies in the United States and internationally. He has also served on many scientific advisory, editorial, and oversight panels, boards, and committees.

Dr. Pope has been the recipient of honors and awards including: Honorary Fellow of the American College of Chest Physicians (2008); Thomas T. Mercer Joint Prize from the American Association for Aerosol Research and the International Society for Aerosols in

Medicine (2001); Utah Governor's Medal for Science & Technology (2004); and BYU's Karl G. Maeser Excellence in Research and Creative Arts Award (1995) and Distinguished Faculty Lecturer Award (2006), among others.

## **AWARDS EVENING LECTURE**

### ***Beauty Redefined***

**Kindsay Kite, Ph.D., and Lexie Kite, Ph.D.**

*Beauty Redefined Foundation*

Lindsay Kite and Lexie Kite are 28-year-old identical twin sisters with PhDs in the study of media and body image from the University of Utah ('13). They have a passion for helping girls and women recognize and reject harmful messages about their bodies and what “beauty” means and looks like. Beauty Redefined represents their not-for-profit work to take back beauty for girls and women everywhere through continuing the discussion about body image, women’s potential, and media influence through their website, Facebook page, and most prominently through regular speaking engagements in both secular and religious settings, from universities and high schools to professional conferences and church congregations for all ages. Their co-authored master’s thesis and complementary doctoral dissertations form the basis for a popular and empowering visual presentation, which has been presented to tens of thousands of people across the U.S. since 2009.

Their blog [www.beautyredefined.net](http://www.beautyredefined.net) provides information about their research and practical ways to recognize, reject, and resist harmful messages about female bodies.

## HONORARY MEMBER

**Linda C. Smith**

*Repertory Dance Theatre*

A native of Utah, Linda began her career in dance at the age of four with Virginia Tanner's Children's Dance Theatre. In 1966, she became a founding member of Repertory Dance Theatre, where she fulfilled her dream of becoming a performer, teacher, choreographer, writer, producer, and eventually, in 1983, the Artistic Director for the company. In 1995, she was named Executive/Artistic Director of RDT.

Her pursuits have led to the development of the Rose Wagner Performing Arts Center, to the establishment of the RDT Community School, to providing commissions for established and emerging choreographers, and to the creation of multi-disciplinary activities that focus on the dance history, the environment, social issues, multi-ethnic history, sustainability, and community. Linda's performing experience spans over 90 works. She has taught in over 1000 schools, bringing the magic of dance to students and teachers with her unique demonstrations, lectures, classes and professional development workshops.

Evidence of her commitment to dance preservation is seen in RDT's collection of historic dance reconstructions that includes choreography by 100 of America's most revered choreographers. In the early 1980s, Linda initiated the development of a historical perspective, *Then, The Early Years*, a retrospective of modern dance classics. RDT now perform *Time Capsule*, a narrated retrospective spanning 100 years of modern dance.

Linda has dedicated her life to finding ways to make the arts relevant and to communicating the value of dance in the life of a community. She is most at home encouraging audiences of all ages to imagine, create and communicate with the language of movement.

## 2014 BEST PAPER AWARDS

### Biology

#### **Microbial Screening of Potable Water Sources in Guatemala: A Potential Source of Disease Transmission**

Emma Bentley, Craig Oberg, Karen Nokaoka, Matthew Domek & Michelle Culumber

*Weber State University*

### Engineering

#### **Solar Aureole Measurements (SAM) System Control**

Connor George,<sup>1</sup> Gene Ware,<sup>1</sup> Doran Baker,<sup>1</sup> A.T. Stair Jr.,<sup>2</sup> Dennis Villanucci<sup>2</sup>

<sup>1</sup>Utah State University, <sup>2</sup>Visidyne, Inc.

### Exercise Science and Outdoor Recreation

#### **Psychological Momentum in Sporting Events**

M. Vinson Miner

*Utah Valley University*

### Letters—Humanities, Philosophy, and Foreign Language

#### **Female Guards, Nurses, and Doctors in German Concentration Camps**

Hans-Wilhelm Kelling

*Brigham Young University*

### Letters—Language and Literature

#### **Heavenly Objects: Stein, Saints and Statues in Four Saints in Three Acts**

Jennifer Large Seagrave

*University of Utah, University of Phoenix*

Physical Sciences

**Assessing the Observability of Hypernova and Pair-Instability Supernova in the Early Universe**

Brandon Wiggins

*Brigham Young University*

Social Sciences

**A Cross-Sectional Study of the Social-networking Behaviors of Electronic Cigarette E-Forum Users**

James Bemel, Heidi McPhie, and Jamie Slade

*Utah Valley University*



# Edge Effect on Mycorrhizal Infection Occurrence in *Gutierrezia sarothrae* [Asteraceae]

Shannon M. Call

*Weber State University*

## Abstract

*Mycorrhizas are mutualistic relationships between fungi and vascular plants. Mycorrhizal associations are important for plants because they provide minerals, especially phosphorous, and water, while the plant provides carbohydrates for the fungi. Trail edges affect plant community diversity by altering water runoff and soil moisture or encouraging growth of invasive species. Because trail edges impact plant communities, I hypothesize mycorrhizal colonization frequency may decrease as distance to a trail edge decreases. To test this hypothesis, *Gutierrezia sarothrae* [Asteraceae], a woody shrub native to the western United States, was sampled from two similar sites and at three distances from hiking trails and mycorrhizal colonization frequency was determined. Plant samples were collected 1 m, 10 m., and 20 m from the edge of the hiking trail. Roots were cleared and stained with trypan blue. A statistical significance overall was determined via chi-square analysis ( $p < 0.0001$ ;  $X^2 = 47.41$ ;  $df = 2$ ). It is important to note, after the study*

*was completed, old aerial photographs were discovered showing the existence 10 years earlier of a hiking trail intersecting site B at the 20-meter sample location. This trail had since been abandoned at the time of the study. Based on the elucidation of an old trail, the hypothesis was subsequently supported by illustrating the long-term effect on the microscopic community. The results showed differential mycorrhizal colonization frequency, suggesting a negative response near trail edges. Understanding how mycorrhizas respond to disturbance can help land managers understand the effects of recreational land use on plant communities.*

## Introduction

Roots provide numerous functions for vascular plants, including nutrient storage, anchorage and absorption and have developed various morphological adaptations due to environmental factors (Leake 1994). Water absorption is critical for all plants; feeder root function is involved in water acquisition. Vascular plants develop a symbiotic relationship with certain fungi called mycorrhizas. Evolutionarily mycorrhizal infections initially may not have been symbiotic; however, they have developed into a beneficial relationship for both vascular plants and fungi (Willis et al. 2013).

Mycorrhizal hyphae grow into roots of vascular plants to take advantage of the nutrients plants store, especially carbohydrates. Mycorrhizas help provide additional minerals and water for the plant because of fungal hyphae surface-to-volume ratio. Mycorrhizal associations occur in two types: intracellular associations in the form of arbuscular mycorrhizas and intercellular associations as ectomycorrhizas (Brundrett 2008). Arbuscular mycorrhizas penetrate the cells of roots, but not cellular organelles, occurring only in the protoplast and ectomycorrhizal hyphae surround individual cells. Both forms of mycorrhizas are able to take advantage of nutrients provided by the plant. Because mycorrhizas provide such an important role in exchange, most plants form these associations.

For this study, *Gutierrezia sarothrae* was selected, as it is a common plant in the Western United States. *G. sarothrae* provides a prime specimen for studying colonization rates because it is widespread and because the plant forms mycorrhizal associations, mainly in the form of arbuscular mycorrhizal (Rillig and Allen 1998).

Many areas disturbed by trails experience increased erosion, loss of diversity, and increased water run-off. This disturbance may make it difficult for plants to thrive near trail edges, and plants may form a

lower frequency of mycorrhizal associations. Because of the disturbance level occurring in the form of excessive trail usage at both sites within the study, I hypothesize there will be a lower rate of mycorrhizal infection closer to the trail and a higher infection rate farther from a trail.

## Materials and Methods

### *Site Description*

Samples of *G. sarothrae* were selected from two sites. The first site, site A, was located on the East bench in Ogden, Utah, near Weber State University. This site was considered disturbed because of two trails running through the area. Four plants each from 1 meter, 10 meters, and 20 meters were collected, totaling 3 groups and 12 plants.

The second site, site B, was similar in elevation, disturbance level, and plant species present. This site was located directly east of 29<sup>th</sup> Street in Ogden, Utah, directly off the main trail approximately 400 meters from the trailhead. This site had one trail running from northeast to southwest. Four plants were selected at 1 meter, 10 meters, and 20 meters away from the main trail, totaling 3 groups and 12 plants. Twenty-four plants from both sites combined were observed.

### *Sample Processing*

Samples were collected and refrigerated 24 hours before analysis. The entire plant and surrounding soil was kept intact. Root samples were then soaked in warm water to remove excess soil without disturbing the fine roots. Roots samples were stored overnight in a 2.5% potassium hydroxide solution. The next day, the roots were rinsed with distilled water three times, then soaked in 1% hydrochloric acid solution for 15 minutes. Fresh trypan blue stain (0.05% trypan), a fungal-specific stain, was prepared, and the roots were left in the stain at room temperature for several days. After staining, the roots were rinsed with an acidified glycerol de-stain solution (500 ml of glycerin, 450 ml of distilled water, and 50 ml of 1% hydrochloric acid) and allowed to soak in the solution for three days. Fresh de-stain solution was added each day, and the roots were rinsed with de-stain solution several times per day until completion. After de-staining, the roots were mounted on microscope slides in lactoglycerol (1:1:1 lactic acid:glacial acetic acid:glycerol) and sealed with clear fingernail polish. A phase contrast microscope was used to observe root samples at 400× magnification using phase contrast.

Chi-square analysis was used to test for statistical difference between groups for the 14.9 mm of roots being observed. Using the optical micrometer as a transect, mycorrhizas were counted only if the hyphae intersected the transect at whole numbers, which included 0, 10, 20, 30, 40, 50, and 60, yielding 7 potential occurrences along each transect; those that intersected at other points were not counted. Because infection occurrence was recorded as colonized or not, non-numerical data was best suited for a chi-square analysis.

## Results

The number of occurrences of hyphae crossing transects was counted. A large data set was collected to allow for a higher probability of chi-square accuracy. Both sites combined exhibited 1,640 hyphal transect intersection points out of 2,079 possible occurrences. Data, defined as the occurrence of hyphal intersections, was analyzed by grouping like samples together.

Data from both sites were combined throughout analysis. Based on the chi-square results, a significant difference in mycorrhizal occurrence was not observed between 1-meter and 10-meter sites ( $p < 0.4463$ ;  $X^2 = 0.58$ ;  $df = 1$ ). A significant difference between 10-meter and 20-meter sites was observed ( $p < 0.0001$ ;  $X^2 = 31.98$ ;  $df = 1$ ). A significant difference was observed between samples at 1 meter and 20 meters ( $p < 0.001$ ;  $X^2 = 38.64$ ;  $df = 1$ ). With data combined from both sites, an overall significant difference was observed ( $p < 0.005$ ;  $X^2 = 60.78$ ;  $df = 2$ ) (Fig 1).

To establish an association between both sites, a Cramer's Value was calculated (Cramer's  $V = 0.1955$ ). A regression analysis was

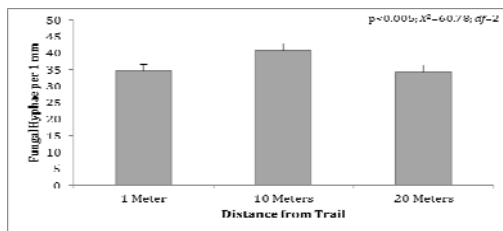


Figure 1. Fungal hyphae count per each group from both sites combined: 518 mycorrhizal hyphae at 1 m, 609 hyphae at 10 m, and 513 hyphae at 20 m. No difference was observed between 1-m and 10-m samples ( $p < 0.4463$ ;  $X^2 = 0.58$ ;  $df = 1$ ). A significant difference was observed between 10 m and 20 m ( $p < 0.0001$ ;  $X^2 = 31.98$ ;  $df = 1$ ). A significant difference was observed between 1 m and 20 m ( $p < 0.001$ ;  $X^2 = 38.64$ ;  $df = 1$ ). Overall, a significant difference between all three groups was observed ( $p < 0.005$ ;  $X^2 = 60.78$ ;  $df = 2$ ).

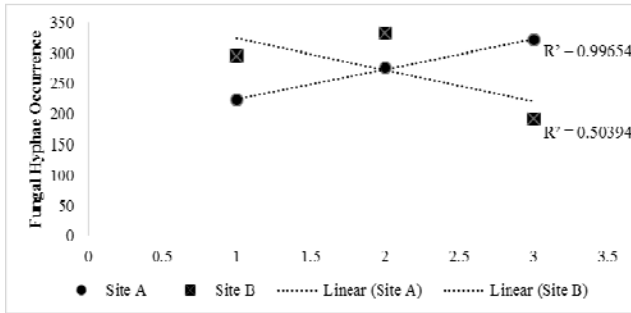


Figure 2. A regression indicated a positive relationship at site A ( $R^2=0.99654$ ); a negative relationship at site B was evaluated ( $R^2=0.50395$ ).

completed at each site. Site A exhibited a positive relationship ( $R^2=0.99654$ ) and site B exhibited a negative relationship ( $R^2=0.50395$ ) (Fig. 2).

## Discussion

A significantly higher occurrence in mycorrhizal infection occurrence in *G. sarothrae* was discovered as distance from a trail edge increased. However, contrary to the hypothesis, hyphal occurrence at the 20-m distance exhibited a significantly lower occurrence than at the 1-m distance ( $p<0.001$ ). Overall the relationship displayed a weak association indicated by the Cramer's V value (0.1955). This may be the result of a small sample size. Further studies with a larger data set need to be evaluated to establish a more representative association. The regression value calculated for each site indicated a positive relationship at site A and a negative relationship at site B. These data at site A were expected, based on the hypothesis that mycorrhizal colonization occurrence will increase as distance to trail edge increases. A negative relationship was elucidated at site B, which was unclear until old aerial photographs were discovered showing the existence 10 years earlier of a hiking trail intersecting site B at the 20-m sample location, indicating a prolonged effect of trails on microbial communities. This trail had since been abandoned at the time of the study (Figure 3).

Most vascular plants form mycorrhizal associations, which may increase plant success. Based on this assumption, it is important to note the differences in size of *G. sarothrae* plants upon arrival during sample collection. Plants located farther from the trails were noticeably smaller in size, were less frequent, and provided lower plant cover than



Figure 3. Site B location illustrates a trail in 2003 (left), that was greatly diminished in 2011 (right).

individuals near the trail edge. This may be due to several reasons. *G. sarothrae* may be able to take advantage of highly disturbed sites, such as along a trail. While mycorrhizal count was lower closer to trails, except group 1-m versus 20-m, *G. sarothrae* may have been able to collect needed nutrients because of lower competition from native and invasive grasses and woody species. In addition to possible reduced competition, increased water run-off may be positively affecting individuals.

Mycorrhizal occurrence of plants located 20 m from the trail at sample site B may have been lower because a hiking trail previously ran through the site. Data collected from site A did not show a decreased association at 20 m. Because the trail at site B was not discovered until after the experiment was completed, a new site was not selected. Distance data were combined during analysis, showing a significant difference between sites. Rather than accepting the null hypothesis of no difference being observed, the discovery of the old trail supported the alternative hypothesis that trails may negatively impact fungal communities. The hypothesis that edge effect affects mycorrhizal occurrence rates is supported through a statistical difference in mycorrhizal hyphae not being observed in plants between a current trail edge and those located on a past trail, located 20 meters from the current trail.

It is also important to note the large distribution of *G. sarothrae* (Ralphs and Wiedmeier 2004). This large distribution supports the notion that *G. sarothrae* is a disturbance strategist species (Lane 1985).

Based on the results of this experiment, I accept the alternative hypothesis that lower mycorrhizal occurrence frequency in roots of *G. sarothrae* occurs when located near a trail edge.

Additional studies need to be conducted in which plants along trail sites are kept separate so hyphal frequency can be determined per plant. This will help reduce the chance of sampling errors, such as plants with an unusual mycorrhizal infection. It would also be interesting to measure mycorrhizal colonization in multiple sites. Additional focus on how *G. sarothrae* responds to climate change, in addition to living in disturbed sites, could lead to a greater understanding of how mycorrhizas are not only affected by microclimate factors, but also by macroclimate variation.

Arbuscular mycorrhizas may often be disregarded or overlooked in comparison to large-scale edge effect studies; however, mycorrhizas play an important role in nutrient acquisition for plants and may have implications for how plants acquire nutrients in the future (Rillig and Allen 1998).

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# Induction of Callus on *Capsicum annuum*: The First Step Toward Micropropagation

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## Abstract

*Micropropagation is important for breeding programs of economically important plants. This research focuses on the establishment of embryogenic callus in *Capsicum annuum*, an economically important plant species. The induction of such callus is the first step toward micropropagation of this species. *C. annuum* produces capsaicin, a chemical that has been approved by the U.S. Food and Drug Administration for treating pain. Culture suspension can increase production of secondary metabolites, in this case capsaicin. In this study two varieties of *C. annuum* (Thai and Jalapeno) were evaluated for their response to different concentrations of indole-3-acetic acid (IAA), 6-benzylaminopurine (BAP), 2,4-dichlorophenoxyacetic acid (2,4-D), and silver nitrate ( $\text{AgNO}_3$ ). These hormones induced callus growth that was qualitatively measured based on the percent coverage of the explant. IAA and  $\text{AgNO}_3$  showed no effect on callus growth. The best callus growth was observed in response to 5  $\mu\text{M}$  BAP and 2.5  $\mu\text{M}$  2,4-D.*

*Fruit extracts were also evaluated to determine the effect on the growth of callus when combined with hormones. The Thai extract had no statistically relevant ( $P=0.1277$ ) effect while the addition of 5% Jalapeno extract did show a significant increase in callus ( $P=0.0159$ ).*

## Introduction

The genus *Capsicum* is a group of annual pepper plants from the Solanaceae family. *Capsicum annuum* is native to Mexico, Central and South America, and the West Indies; however, it is widely cultivated and commercialized around the world. *C. annuum* is an important food crop with medicinal properties. *Capsicum* produces capsaicin, a chemical that has been approved by the U.S. Food and Drug Administration for treating pain; it has been found to have antioxidant properties that can help fight the carcinogen nitrosamine and has shown anti-tumor activity in colon cancer studies (Lu et al. 2010). A different study, done *in vitro*, shows that pepper extracts are effective at activating caspase-3/7, which causes apoptosis in some breast cancer and leukemia cell lines while causing little disturbance in normal cells (Dou et al. 2011). *C. annuum* has also been shown to have an antibacterial property, which explains why it has been used in native pharmacopeia (Koffi-Nevry et al., 2012).

There are different commercially available varieties of *C. annuum*. These varieties can differ in the size of the plant, the capsaicin content, and other morphological characteristics. The two varieties of *C. annuum* used in this study, Thai and Jalapeno, vary widely in their capsaicin content, which determines pungency (spiciness). This pungency can be measured using Scoville units: Jalapeno up to 9,000 units and Thai up to 100,000 units. These units are obtained by diluting a pepper sample until its heat can no longer be noticed; one unit is equal to one dilution (Bosland and Walker 2010).

This research provides valuable information for the micropropagation of these economically important varieties. Micropropagation is important for breeding programs of plants such as *C. annuum*. It allows for a faster and more cost-effective way to propagate plants, and it helps propagate plants that have low seed production. In addition, it allows the induction of somatic embryos useful for large-scale propagation and genetic manipulation of plants. *In-vitro* culture is a great alternative to overcome the inconsistencies in secondary metabolite production in field-grown plants. In addition, culture suspension can increase production of secondary metabolites, in this case capsaicin.

Auxins and cytokinins are signaling molecules that control plant

growth and development. The ratio of formation of roots and shoots depends on the cytokinin:auxin ratio. Organogenesis can usually be regulated by changes in the relative concentrations of these hormones (Moubayidin et al. 2009). Silver nitrate ( $\text{AgNO}_3$ ) has been shown to inhibit ethylene biosynthesis. Ethylene is responsible for senescence due to exudation of phenolics resulting from the wounds done to the tissue when the explants are excised. In addition,  $\text{AgNO}_3$  has been shown to improve somato- and organogenesis (Kotsias and Roussos 2001) of many species.

The purpose of this research is to establish a reliable micropropagation protocol for the Jalapeno and Thai varieties of *C. annum*, which could also be applied to other varieties as well. The ability of these varieties to respond to varying concentrations of indole-3-acetic acid (IAA), 6-benzylaminopurine (BAP), 2,4-dichloro-phenoxyacetic acid (2,4-D), and silver nitrate ( $\text{AgNO}_3$ ) was tested.

## Methodology

### *Explant Preparation*

Young leaves from the top of each branch, similar in size, were surface sterilized with 70% ethanol for 30 seconds and then—subsequently rinsed with sterile distilled water. After this, the leaves were disinfected in 0.48% sodium hypochlorite solution with one drop of Tween or Triton-X (as surfactant agent) for 15 minutes, followed by 4 rinses with sterile distilled water. The disinfected leaves were stored in deionized water until explants were cut to approximately 5 mm<sup>2</sup>.

Callus growth on explants was qualitatively judged on a scale of 0–6. A value of 0 represented no callus growth while a value of 5 meant that 100% of the explant was covered in callus. A value of 6 represented that the entire explant was covered in callus, but there was additional growth of callus beyond full coverage.

### *Preliminary Experiment*

Solid MS (Murashige and Skoog 1962) medium was prepared according to the manufacturer's instructions (PhytoTechnology Laboratories, Shawnee Mission, KS). The pH of the medium was adjusted to 5.7, and hormones were then added to each individual treatment as described.

In the initial experiment, the effect of IAA and BAP was evaluated, and the second experiment evaluated the effects of  $\text{AgNO}_3$  and 2,4-D (Sigma-Aldrich, St. Louis, MO). Each experiment consisted of eight treatments to assess which hormones induced callus growth. Trial

1 treatments began at 0  $\mu\text{M}$  IAA and 0  $\mu\text{M}$  BAP and ended with maximum concentrations of 5.71  $\mu\text{M}$  IAA and 22.20  $\mu\text{M}$  BAP. Trial 2 began with a similar control of 0  $\mu\text{M}$   $\text{AgNO}_3$  and 0  $\mu\text{M}$  2,4-D, but ended with maximum concentrations of only 5.89  $\mu\text{M}$   $\text{AgNO}_3$  and 9.05  $\mu\text{M}$  2,4-D. There were five plates per treatment, with the abaxial side of the explants making contact with the media. The explants were maintained in the dark because previous experiments showed that explants in light did not develop callus; however, they seemed to respond well when placed in the darkness.

### *Determining Ideal BAP and 2,4-D Concentration*

Different concentrations of BAP and 2,4-D were tested to evaluate callus growth response. Each treatment included eight replicates (Table 1).

<b>Table 1. Concentrations of BAP and 2,4-D used to evaluate callus growth in <i>Capsicum annuum</i></b>	
<b>Treatment</b>	<b>Concentration</b>
1	0 $\mu\text{M}$ BAP 0 $\mu\text{M}$ 2,4-D
2	5 $\mu\text{M}$ BAP 0 $\mu\text{M}$ 2,4-D
3	0 $\mu\text{M}$ BAP 2.5 $\mu\text{M}$ 2,4-D
4	5 $\mu\text{M}$ BAP 2.5 $\mu\text{M}$ 2,4-D
5	0 $\mu\text{M}$ BAP 5 $\mu\text{M}$ 2,4-D
6	5 $\mu\text{M}$ BAP 5 $\mu\text{M}$ 2,4-D

### *Effect of Fruit Extract on Callus Growth*

Thai and Jalapeno fruit (10 g each) was harvested, blended with 100 ml of  $\text{dH}_2\text{O}$ , and then strained. The slurry was then filter sterilized using a VWR Vacuum Filtration System (Radnor, PA; Catalog number: 87006-064). MS medium was prepared following the manufacturer's recommendations; after autoclaving, the media was amended with 5  $\mu\text{M}$  BAP and 2.5  $\mu\text{M}$  2,4-D and either 5% or 10% fruit extract. The control contained only BAP and 2,4-D but no extract. Each variety was evaluated for its response to its own extract. Each treatment had four replications with one explant per replication (Table 2).

## **Results**

### *Preliminary Experiment*

The hormones that were chosen were based on the preliminary

<b>Table 2. Fruit extract treatment concentrations used to evaluate callus response</b>	
<b>Treatment</b>	<b>Fruit Extract Concentration</b>
1	0% Thai
2	5% Thai
3	10% Thai
4	0% Jalapeno
5	5% Jalapeno
6	10% Jalapeno

Treatments 1–3 were used for the Thai explants whereas treatments 4–6 were used for the Jalapeno variety.

studies done in our laboratory. Because Thai and Jalapeno varieties had virtually no response to the IAA and BAP treatments, we hypothesized that changing the IAA for another auxin could have a positive effect so further experiments were done with 2,4-D. No callus was produced when only  $\text{AgNO}_3$  was added to the media.

### *Ideal BAP and 2,4-D Concentration*

The second experiment was done to find the ideal concentration of BAP and 2,4-D. The treatment using 5  $\mu\text{M}$  BAP and 2.5  $\mu\text{M}$  2,4-D resulted in better average callus production than the other treatments. All Jalapeno explants developed necrosis so their results are not shown. A two-factor ANOVA analysis of the callus growth of the Thai variety was done using SAS statistical software (Figure 1).

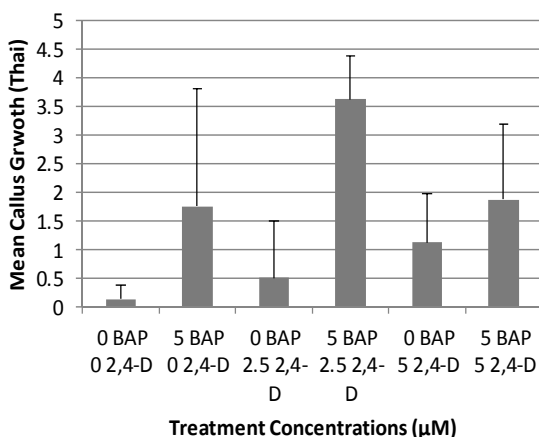


Figure 1. Average callus growth on BAP and 2,4D for the Thai variety

The two-factor ANOVA showed that only altering concentration of BAP had a statistically significant effect on the callus growth ( $P=0.0013$ ), whereas the 2,4-D ( $P=0.1902$ ) as well as the interaction between BAP and 2,4-D ( $P=0.1542$ ) had no statistical effect on the callus growth. A Tukey analysis was performed; however, because of the conservative nature of the test and the small sample size the results were inconclusive.

### *Effect of Fruit Extract on Callus Growth*

The concentration of BAP ( $5\text{ }\mu\text{M}$ ) and 2,4-D ( $2.5\text{ }\mu\text{M}$ ) was selected for the evaluation of fruit extract on morphogenesis because this treatment showed the best average callus growth. The data for both the

Thai explants on Thai fruit extract and the Jalapeno explants on Jalapeno fruit extract was analyzed using single-factor ANOVAs (Figure 2).

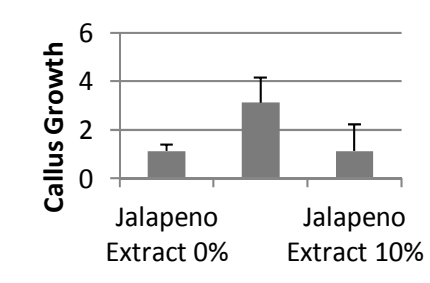


Figure 2. Average callus growth in the Jalapeno variety in response to different concentrations of Jalapeno fruit extract.

The ANOVA indicated that there was a statistically significant difference in the response between the three groups ( $P=0.0159$ ) of Jalapeno extract. It is interesting to note that the 0% fruit extract and the 10% fruit extract had the same mean callus growth (1.125), showing that the 5% fruit extract was responsible for the statistical significance. The Thai extract did not show a significant additional effect on callus growth when added to media that had been amended with BAP and 2,4-D ( $P=0.1277$ ) (Figures 3 and 4).

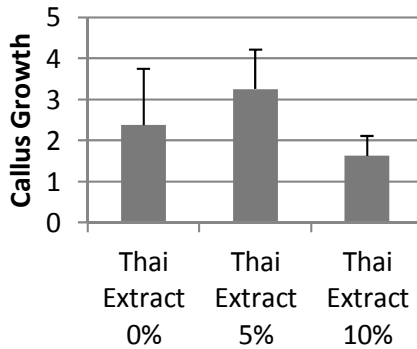


Figure 3. Average callus growth in the Thai variety in response to different concentrations of Thai fruit extract.

## Discussion

### *Preliminary experiment*

The Thai and Jalapeno varieties responded favorably when on media containing only 2,4-D but did not respond when plated onto media with only  $\text{AgNO}_3$ . Sanatombi and Sharma (2007) used IAA to assist in rooting rather than in callus proliferation or organogenesis, which may explain why callus was not formed when only the auxin IAA was used. Silver nitrate is also commonly used in later tissue culture processes (Kothari et al. 2010).

### *Ideal BAP and 2,4-D Concentration*

A troubleshooting experiment showed that the sterilization process and the media were not responsible for the necrosis of the Jalapeno explants. BAP was found to have a positive effect on the growth of callus on Thai explants. This is probably because BAP is a cytokinin whereas 2,4-D is a synthetic auxin. Cytokinins are hormones that promote cell division in plants (Werner et al. 2001), therefore they likely caused the increase in the formation of callus. Callus has been grown on injured *C. frutescence* seeds using a combination of 2,4-D and kinetin (Sudha and Ravishankar 2002). Kinetin, like BAP, is a cytokine; this means that it also promotes cell division that leads to callus formation (Amasino 2005). Kinetin has also been successfully used in axillary shoot micropropagation of *C. frutescence* (Sanatombi and Sharma 2007). Gudeva et al. (2013) also used kinetin and 2,4-D plates when testing capsaicin's inhibitory abilities. It should

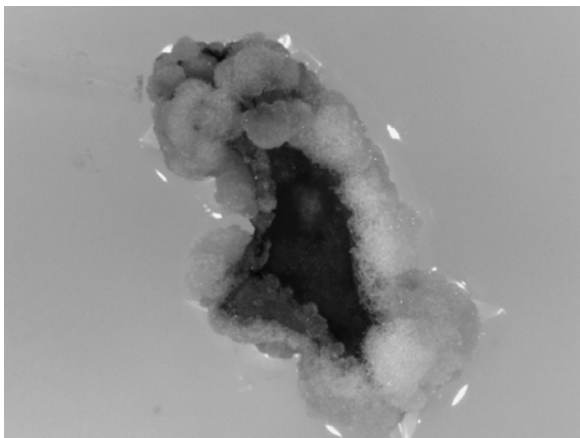


Figure 4. Callus formation on Thai leaf explant grown in MS media amended with 5  $\mu$ M BAP, 0  $\mu$ M 2,4-D.

be noted that Gururaj et al. (2004) reported that 2,4-D and NAA were not effective for shoot proliferation when combined with kinetin. Because BAP and kinetin are both cytokinins, they should both have a similar effect on the growth of callus; however, kinetin should still be tested to discover which cytokine has a better effect on *C. annuum* callus growth. Although our results showed that 2,4-D had no effect on callus growth, auxins have been hypothesized to have a role in many areas of plant growth and development (Dharmasiri et al. 2005). Considering this, the effects of the 2,4-D (because it is a synthetic auxin) may not be seen until later in the micropropagation procedure. The same may hold true for the interaction between the BAP and 2,4-D; Martin et al. (2000) indicated that a balance of cytokinins and auxins is necessary for efficient induction and differentiation. This study has mostly used varying concentrations of BAP and more of a fixed concentration of 2,4-D, because of results from preliminary experiments.

### *Fruit Extract Experiment*

Coconut water has been shown to be useful in other plant tissue cultures because it helps promote growth because of the phytohormones content that can be used as growth regulators (Yong et al. 2009, Zhen et al. 2008). The same may be true for other fruit extracts, including peppers. The results showed that Thai fruit extract had no significant effect on the growth of callus on the explants. This may have been because mature red peppers were used when creating the extract. Thai explants showed no statistically significant differences in response to

Thai fruit extract (Figures 3 and 4). Nonetheless, all treatments showed good callus growth. The lack of differential response could be due to the higher amount of capsaicin found in this pepper or to insensitivity to the metabolites present in the extract. Gudeva et al. (2013) found that peppers with higher amounts of capsaicin produced little to no callused or embryogenic anthers in their studies. On the other hand, the Jalapeno 5% plates did have significant growth. To test whether the lack of Thai growth is due to the higher amount of capsaicin, Thai explants should be plated onto Jalapeno fruit extract at the same concentrations as before.

### *Final Conclusions*

These results indicate that MS media amended with 2.5  $\mu$ M 2,4-D and 5  $\mu$ M BAP is the best treatment to induce callus growth on the Thai and Jalapeno varieties of *C. annuum*. When this medium was used, the addition of mature Thai fruit extract did not show significant increase in callus growth, whereas the addition of 5% Jalapeno fruit extract showed significant growth of callus in Jalapeno explants. This research presents a useful method of callus production in *C. annuum* that shows promise in different varieties of pepper.

### **Future Work**

Explants will be transferred to MSO media (Samoylov et al. 1998). A wide range of BAP concentrations will be tested in conjunction with 2.5  $\mu$ M 2,4-D to determine whether higher concentrations of BAP increase callus growth or inhibit the induction of callus. Other growth regulators responsible for inducing embryogenesis will be evaluated.

### **Acknowledgments**

We acknowledge Nellie Myatt, Jamison Wethall, and David Garcia for the preliminary experiments. Statistical analysis thanks to Eric Heiny.

Funding from this research was provided by scholarly activities grant (SHS 028) from Utah Valley University.

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# Microbial Screening of Potable Water Sources in Guatemala, a Potential Source of Disease Transmission

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## **Abstract**

*Transmission of infectious diseases by fecally contaminated water represents a reoccurring health risk for the local populations in rural Guatemala and has serious implications for travelers from developed nations. The presence of coliforms and Escherichia coli in water are indicators of fecal contamination, and possibly, the presence of fecally transmitted pathogens. In this study, the degree of fecal contamination in potable water designated for drinking, washing, or both was determined by screening 27 samples collected in four different locations: Guatemala City, Chulac, El Estor, and Flores. Samples taken of water from a wide variety of potable water sources, both urban and rural, were plated on Total Coliform, Enterobacteriaceae, and E. coli/Coliform Petrifilms. Inoculated Petrifilms were incubated at ambient temperatures, and colonies were counted at 24 and 48 hours. Re-*

sults showed that 92.6% of the water sources contained bacteria, 48.1% of samples contained coliforms, 14.8% contained *E. coli*, and 70.4% were positive for *Enterobacteriaceae*, possibly indicative of *Salmonella* contamination. Coliform counts ranged from 0 to  $>1.6 \times 10^2$  CFU/mL and *E. coli* counts from 0 to  $>1.2 \times 10^2$  CFU/mL of potable water. These results indicate that potable sources, particularly in rural areas such as Chulac, could be a significant source of fecal pathogen transmission to its consumers.

## Introduction

Worldwide, more than 1.1 billion people lack access to potable water, meaning water considered safe for human consumption, which includes a household connection, a protected dug well, rain water collection, a protected spring, or a borehole (1). In 2007, it was noted that 90% of urban populations and 60% of rural populations had improved access to drinking water in Guatemala. Although this indicated an improvement compared with conditions in 2002, access to clean water was still a major health concern, particularly in rural areas (2). In Guatemala, water services are frequently interrupted, water pressure is insufficient, and tap water is often unsafe to drink (3). Water may be unsafe to drink even if adequately treated, since breaches can occur in the water distribution system, allowing potential pathogens to enter piped water prior to human consumption (4).

In addition to complications with delivering potable water, countries like Guatemala may experience heavy rains or wet seasons. In Guatemala City, the rainy season occurs from July to October, with rainfall probability reaching over 70%, and the average annual precipitation is 51.8 inches (6). Regions with such wet climates may experience flooding, which could allow sewage to enter drinking water at any point in the rural water delivery system, providing a pathway for numerous pathogenic waterborne organisms to enter a community's water supply (5). Such weather-related factors increase the risk for major waterborne diseases, including bacterial diarrhea, which could adversely affect Guatemalans' health, as well as that of travelers (7).

Worldwide, diarrhea is the second most common cause for morbidity and death in children <5 years old (8). The World Health Organization (WHO) reports that diarrheal disease will be the major factor in over 1.8 million deaths annually by 2015, for all ages and both sexes (9). Although data vary from study to study, viral pathogens such as rotavirus are considered the most common diarrhea-causing agents, but bacterial pathogens such as *Shigella* and pathogenic *Escherichia*

*coli* are second, with other bacterial pathogens such as *Aeromonas* and *Vibrio cholerae* being important in specific regions (10).

Traveler's diarrhea (TD), the most common illness experienced by people traveling to other countries, is also of concern when discussing the water conditions in Guatemala (11, 12). TD, which causes a disability period of at least 24 hours and often continues for days to weeks, is usually treatable with antibiotics (14). Studies show that 45% of TD cases originate in developing countries such as Guatemala and that bacterial pathogens are implicated in over 80% of TD cases (13). Enterotoxigenic *E. coli* (ETEC) has been found to be the etiologic agent in 34% of TD cases, with enteroaggregative *E. coli* (EAEC) causing 24% of the TD cases in Latin America (15). This prevalence of TD underscores the importance of monitoring potable water for *E. coli* and coliforms.

Diarrheal diseases in Guatemala can be attributed to numerous factors, such as consumption of fecally contaminated water, a deficiency of potable water, poverty, and a lack of education. In rural Guatemala, the responsibility to universalize access to basic needs such as drinking water and sanitation has been decentralized to municipal governments in recent years (16). To our knowledge, there is no current standard enforced by the Guatemalan government that regulates allowable bacteria in drinking water; however, standards from the U.S. Environmental Protection Agency (EPA) recommend a total coliform, fecal coliform, and *E. coli* count of zero. The U.S. EPA requires that less than 5% of water samples test positive for coliforms, with a maximum of one positive sample if fewer than 40 samples are taken in a month (17). The drinking water standards in place by the WHO are similar (18).

Guatemala, the most populous country in Central America at over 14 million people and the highest growth rate in Latin America, is a predominantly poor country, struggling with public health (7). While Guatemala is not the poorest country in Central America, one of the challenges Guatemala faces is reducing the rural and indigenous poverty level below the current level of 56% (2). Interestingly, studies suggest that poverty level is linked to having access to potable water (19). Another issue is that Guatemala has the highest rate of malnutrition in both Central America and the Western Hemisphere and the fourth highest rate in the world (20). In certain regions of Guatemala, the deadly combination of widespread poverty, malnutrition, and unclean water increases the prevalence of diarrheal diseases, which are also linked to secondary health issues, such as reduced cognitive functioning and exacerbation of pre-existing malnutrition (1). As children develop, enteric diseases that result in overt diarrhea also contribute in the

long term to growth retardation and stunting (21, 22, 23, 24). In specific reference to Guatemala, from 2005 to 2012, the WHO reported that 48% of children under the age of 5 years were stunted in their growth (8).

The purpose of this study was to obtain baseline data regarding the level of microbial contamination of potable water in Guatemala. Various urban and rural potable water sources were analyzed using Petrifilms, and isolates obtained were typed by 16S rRNA sequencing to determine their identity. Potable water sources were screened for the presence of total bacteria, *E. coli*, total coliforms, and Enterobacteriaceae. After screening the water sources, microorganisms isolated from the Petrifilm plates were evaluated for their potential to act as human pathogens.

## Materials and Methods

### *Sampling Areas*

Four areas, representing different environments, were selected in Guatemala for sample acquisition: Guatemala City, Flores, El Estor, and Chulac (Figure 1). Guatemala City is the national capital and has a population of nearly one million people. Flores is a tourist town with over 20,000 residents. El Estor is a moderately small town with an estimated population of over 15,000 people. Chulac, with no available population data, is a rural area isolated from most commercial ventures.

In this study, sampling of water was done whenever a source was located, leading to the sampling of 27 courses in rural and urban Guatemala. Because the definition of potable water differs between natives and travelers, water was sampled generously, and later specified as potable or not depending on location, access to the water and actual usage of the water by local residents as observed by the researchers. For instance, a resident of the rural area of Chulac considers all water to be potable, while an American traveler would not drink from a washbasin that had been used for bathing. As such, typical water sources used in this study included hand washing facilities, water used for general washing and cleaning, and water used for drinking or cooking.

### *Sampling Procedure*

Approximately 5 mL of water was taken from each of 27 water sources (Table 1). Approximately half of the samples were obtained in



Figure 1. Sampling regions in Guatemala

Chulac, the most isolated and rural of the four sampling areas. The rest of the samples were obtained in Guatemala City, El Estor, or Flores. At the time of collection, samples were labeled with the location, the type of water source, and the date and time of collection. Samples were taken from a broad spectrum of water sources, including a hospital, commercially bottled water, public spigots, and hand-washing sinks. The focus was on collecting samples from water sources that would be considered potable in the United States, as well as from those that natives treated as potable. All samples were collected in sterile, plastic, flip-cap tubes.

### Sample Analysis

One milliliter of each sample was plated onto Aerobic Count Plate Petrifilm, *E. coli*/Coliform Count Plate Petrifilm, and Enterobacteriaceae Count Plate Petrifilm. All Petrifilm plates were incubated

at ambient temperature since no incubators were available in the test areas. The lack of a modern incubation procedure necessitated two colony count readings be taken, one at 24 hours and a second at 48 hours. Results were interpreted using the specific Interpretation Guide provided by 3M for each type of Petrifilm. Counts for *E. coli* and for total coliforms could be obtained from the same *E. coli*/Coliform Count Plate Petrifilm plate. The presence and concentration of *E. coli* and coliform bacteria were used to evaluate the overall contamination of the

Table 1. Water Sources by Area, Name, Quantity, and Primary Usage Designation							
City	Source Name	Quantity	Usage Categories				
			B	D	W	M	P
Guatemala City (urban)	Bathroom sink	3			X		X
	Bottled water	1	X	X			
	Water jug	1		X			
Chulac (rural)	Bathroom sink	4		X	X	X	X
	Bathroom sink with filter	1		X	X	X	X
	Bottled water	1	X	X			
	Groundwater spigot	1			X		X
	Hand sink	1		X	X	X	X
	House spigot	1		X	X	X	X
	Pila (running water)	3		X	X	X	X
	Pila (standing water)	1			X		X
	Rain catcher	1		X	X	X	
	Roadside spring	1		X	X	X	
	Wash basin	1		X	X	X	X
	Water jug	2		X			
El Estor & Flores (urban)	Bathroom sink	3			X		X
	Served table drink	1		X			

B = bottled, D = drinking, W = washing, M = mixed, P = plumbed

water to assess the potential for disease transmission in potable water sources. This study employed 3M Petrifilm plates, which are approved by the Association of Official Agricultural Chemists (AOAC) as an effective coliform screening tool in the food industry, as an initial indicator of fecal contamination (25).

### *Harvesting Isolates from Petrifilm*

Three methods were used to harvest individual isolates from the Petrifilms for further characterization. The first method used eosin-methylene blue (EMB) agar (Hardy Diagnostics, Santa Maria, CA) RODAC plates, which were pressed down on the exposed surface of the Petrifilm medium after the plastic had been lifted off of the medium surface. This RODAC plate method was used to harvest samples from the *E. coli*/Coliform Count Plate Petrifilms. The second method for sample harvesting was using a sterile loop to pick off individual colonies from the Petrifilm after lifting the protective film from the medium surface. These individual and randomly selected isolates were then streaked on either EMB or violet red bile (VRB) agar (Hardy Diagnostics, Santa Maria, CA). The third harvesting method was creation of a spread plate. The top protective film of the Petrifilm was removed, and the medium was scraped off using a sterile plastic spreader. The medium was then placed in a sterile 9-mL distilled water dilution blank and vortexed to resuspend. One-tenth of a milliliter was then spread plated on an EMB plate.

### *Characterization of Individual Isolates*

Twenty-six samples were taken from the Petrifilms using one of the three methods described. Individual colonies showing typical lactose fermentation morphology on either EMB or VRB agar were selected and streaked again for isolation if the media appeared to contain colonies of differing morphology. Pure cultures (individual colonies) selected for subculture were aseptically transferred into 5 mL of tryptic soy broth (TSB). Broth cultures were gram stained, confirming the isolates to be gram-negative short rods, which could indicate coliforms or possible *Salmonella* strains.

### *Molecular Characterization*

Genomic DNA was extracted from individual broth cultures using the MoBio Ultra Clean Microbial DNA extraction kit (12224-50, Carlsbad, CA). The 16S rRNA gene was amplified using PCR with bacteria specific primers, 27F and 1429R (26). Sequencing was done at

the Idaho State Molecular Research Core Facility (Pocatello, ID). Sequencing was done in both directions resulting in a fragment approximately 1400 bp long. Sequences were compared using BLAST to the GenBank database.

## Results

Average colony counts based on sampling region and the type of water sampled are given in Table 2. Overall higher bacterial counts for both total bacteria and total coliforms per ml of potable water were higher in samples from rural areas. Growth by sampling regions are summarized in Table 3. Overall, 25 of 27 sources (92.6%) were positive for aerobic bacteria. Thirteen of the 27 samples (48.1%) tested positive for coliforms. Four of 27 (14.8%) were positive for presumptive *E. coli* based on Petrifilm data. Enterobacteriaceae were detected in 19 of the 27 samples (70.4%).

<b>Table 2. Average Colony Counts (CFU/mL) Based on Area and</b>						
<b>City</b>	<b>Water Usage Type</b>	<b>Bacteria</b>				<b># Sources Included in Type</b>
		<b>AE</b>	<b>TC</b>	<b>EC</b>	<b>EB</b>	
Guatemala City	B	$>10^3$	0.0	0.0	0.0	1
	D	$>10^3$	0.0	0.0	0.0	2
	W	3.3	0.0	0.0	0.0	3
	P	3.3	0.0	0.0	0.0	3
Chulac	B	1.0	0.0	0.0	0.0	1
	D	1303.3	16.8	12.2	124.8	10
	W	749.9	13.8	8.4	94.9	15
	P	791.2	15.9	9.7	105.2	13
El Estor & Flores	B	n/a				0
	D	$>10^3$	17.0	0.0	240	1
	W	1593.0	4.0	1.0	6.0	3
	P	1593.0	4.0	1.0	6.0	3
Overall Rural	n/a	906.2	11.6	7.0	86.7	18
Overall Urban	n/a	798.0	3.2	0.3	28.7	9

AE = aerobic, TC = total coliform, EC = *E. coli*, EB = Enterobacteriaceae, B = bottled, D = drinking, W = washing, M = mixed, P = plumbed

Table 3. Positive Results by Sampling Area					
Location	Samples	No. AE (%)	No. TC (%)	No. EC (%)	No. EB (%)
Guatemala City	5	3 (60.0)	0 (0.0)	0 (0.0)	0 (0.0)
Chulac	18	18 (100)	10 (55.6)	3 (16.7)	15 (83.3)
El Estor & Flores	4	4 (100)	3 (75.0)	1 (25.0)	4 (100)
Total	27	25 (92.6)	13 (48.1)	4 (14.8)	19 (70.4)

AE = aerobic, TC = total coliform, EC = *E. coli*, EB = Enterobacteriaceae

Chulac had the highest incidence of aerobic growth with 18 of 18 sources (100%) positive for growth. A comparable incidence of bacterial contamination was found in El Estor and Flores, where 4 out of 4 samples (100%) were positive. Water samples from Guatemala City had the lowest incidence for aerobic contamination with only 3 out of 5 samples (60.0%) testing positive (Table 3).

Water samples from both El Estor and Flores had the highest number of coliforms with 3 out of 4 samples (75.0%) testing positive (Table 3). Chulac had 10 out of 18 sources (55.6%) test positive for coliforms while water from Guatemala City showed no coliform growth. El Estor and Flores water samples were also highest for presumptive *E. coli* contamination with 1 positive in 4 samples (25.0%). In Chulac, 3 out of 18 samples (16.7%) tested positive for presumptive *E. coli*, while Guatemala City water samples had no presumptive *E. coli* growth. In regard to Enterobacteriaceae, El Estor and Flores had 4 out of 4 (100%) of water sources test positive, while Chulac had 15 of 18 sources (83.3%) test positive. Guatemala City water samples showed no Enterobacteriaceae growth.

Ranges for the overall bacterial concentrations in water samples testing positive are shown in Table 4. Aerobic bacteria growth ranged from 0 to greater than  $10^4$  CFU/mL. Water sources testing positive for coliform growth ranged from 1 to  $1.6 \times 10^2$  CFU/mL. Presumptive *E. coli* ranged from 0 to  $1.2 \times 10^2$  CFU/mL and Enterobacteriaceae ranged from 0 to  $7.8 \times 10^2$  CFU/mL.

Molecular characterization of random isolates from the Petrifilms revealed that coliforms such as *Enterobacter*, *Klebsiella*, *Plesiomonas*, and *Aeromonas* were present (Table 5).

<b>Table 4. Bacterial Load of Positive Samples</b>	
<b>Petrifilm Count Plate</b>	<b>Range (CFU/mL)</b>
Aerobic	0 to $>10^4$
Coliform	0 to $1.6 \times 10^2$
<i>E. coli</i>	0 to $1.2 \times 10^2$
Enterobacteriaceae	0 to $7.8 \times 10^2$

## Discussion and Conclusions

This study is one of the first to utilize Petrifilms to screen water sources in Guatemala for bacterial contamination as an indicator of potential waterborne disease transmission. While use of Petrifilms plates is not an EPA-approved method for monitoring water quality in the United States, the use of these particular Petrifilms has been approved by the AOAC as a method for monitoring food safety in the food industry. Petrifilm plates were used in this study in response to claims that their use may be an effective screening tool to characterize water quality in locations that are inaccessible to standard laboratory based methods (30, 31). Although this study offers no comparison to laboratory-based (petri plate) methods, Petrifilms were convenient to use for a number of reasons, including size and portability and the ease of initial interpretation of results while in the field. This study is a step to quantify information to determine a methodology that is appropriate for such a task in future experiments. Because this study was intended to be a simple screening of water sources to provide baseline data to the scientific community to aid in future studies, no statistical tests were performed to test the significance of each source sampled, as there were very limited data available on the sources sampled that would be of great use statistically.

The level of contamination in many of these samples, particularly in rural regions, was surprisingly high, given the small sample size taken from each source in comparison to the 100-mL standard as per EPA methods of sampling. It is noteworthy that this level of contamination was detected despite lack of standard incubators or laboratory facilities. Although the lack of incubators can make accurate quantification difficult, the values obtained are valid as a tool for comparison among the sources sampled.

The organisms identified using molecular screening, which may not have been 100% accurate, are those that are commonly isolated

**Table 5. Molecular Screening of Randomly Selected Isolates**

City	Source ID	Molecular Identification	Purpose	Source Type
Chulac	4	<i>Pseudomonas monteilii</i>	Mixed	Wash basin
	5	<i>Plesiomonas shigelloides</i>	Mixed	Roadside spring
	6a	<i>Chromobacterium haemolyticum</i>	Washing	Bathroom sink
	6b	<i>Aeromonas hydrophila</i>	Washing	Bathroom sink
	6c	<i>Aeromonas caviae</i>	Washing	Bathroom sink
	7	<i>Chromobacterium aquaticum</i>	Washing	Bathroom sink
	8	<i>Kluyvera ascorbata</i>	Washing	Bathroom sink with filter
	9	<i>Chromobacterium aquaticum</i>	Mixed	Pila (standing water)
	10a	<i>Pectobacterium carotovorum</i>	Mixed	Pila (running water)
	10b	<i>Chromobacterium aquaticum</i>	Mixed	Pila (running water)
	11a	<i>Citrobacter freundii</i>	Washing	Bathroom sink
	11b	<i>Aeromonas hydrophila</i>	Washing	Bathroom sink
	12a	<i>Pseudomonas alcaliphila</i>	Drinking	Water jug
	12b	<i>Pseudomonas denitrificans</i>	Drinking	Water jug
	19	<i>Enterobacter asburiae</i>	Mixed	Pila (running water)
El Estor	22	<i>Klebsiella pneumoniae</i>	Drinking	Served table drink
Flores	26	<i>Citrobacter freundii</i>	Washing	Bathroom sink

from various types of water, including water taps at the periphery of a water distribution system (34). The coliforms confirmed are often present because of biofilm formation in piped water distal to water treatment plants and other types of water (27, 28). Further, these are potential pathogens that are able to cause diarrhea on rare occasions and that can be especially problematic in immunocompromised individuals (29, 35). Their presence is also important since many of these

organisms are coliforms (*Klebsiella*, *Enterobacter*, etc.), which should not be present in drinking water as per EPA standards. Thus, their presence may be indicative of the potential risk of ingesting other pathogenic organisms, such as EPEC, ETEC, and *Shigella*, or, at a minimum, their presence may alter the taste of the water (36).

Many water quality experts suggest that positive *E. coli* results, which were presumed in 14.8% of the samples we tested, are the greatest indicator of pathogen risk in comparison to only positive coliforms, since presence of coliforms alone is not as reliable for predicting other pathogens such as *Salmonella*, *Shigella*, or pathogenic *E. coli* (32). If these experts are correct, then there would be risk of encountering organisms such as *Salmonella*, *Shigella*, or pathogenic *E. coli* in three locations in Chulac and one location in El Estor and Flores (Table 3).

It is of great importance that the results of this survey indicated that the smaller cities and rural regions in Guatemala continue to suffer with contaminated water sources, while in urban areas of Guatemala, the water is less likely to carry disease-causing microorganisms (Table 2). This study also has worldwide implications since the high prevalence of TD acquired in developing regions, as in certain regions of Guatemala, affects millions of tourists every year (15). Based on these findings, those traveling to developing countries for either personal or humanitarian reasons should note that consumption of supposedly potable water in small cities or rural locations may place the traveler at increased risk of diarrhea.

Molecular characterization of our cultures did not identify common waterborne pathogens such as *E. coli*, *Salmonella*, and *Shigella*. This may be explained by a number of reasons. First, there was a delay of up to a week from the time of initial culture on Petrifilms to subculturing attempts. These enterics are not hardy outside the host's gastrointestinal tract (33). Thus, it is possible that these organisms may not have survived the transport conditions, including conditions in the airplane's cargo hold. Secondly, only a few randomly selected isolates were chosen for molecular identification. This technique of random sampling limited the sample size, possibly explaining the failure to detect these particular pathogens. More inclusive sampling of the plates might have yielded these organisms. Third, by sampling only 1 mL of water instead of 100 mL of water as recommended by the EPA, these pathogens may have been missed or, in some cases, obscured by the plethora of other bacteria present even in 1 mL of sample. We suggest that similar studies should attempt to isolate the colonies in the field instead of delaying the subculturing. Another tactic would be to use specific primers that would enhance not only identification of these

from other coliforms as well as primers that may be able to characterize specific pathogenic groups (i.e., ETEC from EAEC).

These reasons do not adequately explain the lack of molecular characterization to identify *E. coli* from the samples. In fact, this is an anomaly since there was significant growth on several *E. coli*/coliform plates indicative of *E. coli* since a blue colony with gas and blue precipitate indicates production of glucuronidase, an enzyme fairly unique to most *E. coli*. The culture-based results fit with other studies since *E. coli* strains have been found to be common in Central America, and *E. coli* is isolated from 76% of TD cases. Therefore, it is likely that the coliform and presumptive *E. coli* bacterial counts observed in this study on Petrifilms could be confirmed as *E. coli* (13). This would be plausible with the given history, as ETEC has been the most significant cause of TD since the 1970s (14).

The accepted public health model is that safe water, adequate sanitation, and personal hygiene all contribute to preventing diarrhea and that deficiencies in these variables have been attributed to 88% of global diarrheal deaths (37). Rural Guatemala continues to face obstacles that hinder the population's progress towards having and maintaining clean water. One obstacle is that Guatemala's public health expenditure is among the lowest in the Americas at around 1% of gross domestic product (2). Another challenge for Guatemala is poverty. Income levels are directly related to water cleanliness and better housing conditions, including adequate sanitation and improved water supply (37). As Guatemala continues to develop as a nation and improve its public health, the rural population may one day have water that exhibits the characteristics found in urban Guatemala.

One factor relating to the future success in the health of the Guatemalan people that may be underestimated is educational awareness. Although there are data on the effects of education and its positive impact on overall health, little was observed concerning efforts to educate communities about water cleanliness, methods to clean their water, or how to maintain clean water. It has been observed that maternal academic skills are associated with improved management of childhood diarrhea (38), further supporting the observation that if education is in place, there can be a positive impact on childhood health, which can follow through to adulthood.

Improvement of potable water sources, particularly in rural areas, in future years may result in a decrease in deaths due to factors associated with water-borne diseases. The WHO projects that by 2030, for all age groups and sexes in the world, 1.6 million deaths annually will be from diarrheal disease (20). While this is lower than currently projected for 2015, continued monitoring of potable water to encourage im-

provement of these sources could further improve health in developing countries.

## Acknowledgments

I would like to thank the Department of Microbiology at Weber State University College of Science for supplying materials, expertise, and their full support as well as the invaluable mentoring provided by Dr. Craig Oberg and Dr. Karen Nakaoka in connection with this research project.

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# **Chytridiomycosis Infection Rates in *Hyla arenicolor* in Zion National Park**

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## **Abstract**

*Previous studies of canyon tree frogs (*Hyla arenicolor*) in Zion National Park (ZNP) have shown that some populations test positive for a dangerous fungus in the Chytridiomycosis family. This fungus has been linked to large population losses worldwide in many keystone amphibian species, but its effect on populations of *H. arenicolor* remains to be determined. Since chytrid fungal growth is inhibited at high temperatures, we hypothesized the frogs are able to rid themselves of the fungus because they bask in the sun. During summer 2013, we swabbed frogs and recorded skin temperatures in multiple slot canyons in ZNP to test for the presence of the fungus. Skin temperatures were as high as 38°C, which is above the previously established lethal threshold of 28°C for Chytridiomycosis. Whether this is a behavioral mechanism that confers chytrid resistance in canyon tree frogs remains to be determined. If further research supports these findings, it could lead to more effective allocation of limited conservation resources.*

## Introduction

Chytridiomycosis (chytrid) contributes to the decline of amphibian populations, specifically to simultaneous localized extinctions. After amphibian population declines began in the late 20th century, chytrid emerged as the main cause (Skerratt et al. 2007; Rosa et al. 2013). Chytrid is a critical threat to biodiversity and is responsible for the greatest biodiversity loss in recorded history (Skerratt et al. 2007; Rohr and Raffel 2010). Chytrid, which is specific to amphibians, is caused by the aquatic fungal pathogen *Batrachochytrium dendrobatidis* (Pessier, 2002). Chytrid infection leads to abnormal epidermal sloughing and sometimes epidermal ulceration or hemorrhaging. All of these effects lead to death (Daszak et al. 2003).

Rapid deaths following infection are functions of the reproductive patterns of chytrid. The fungus reproduces via zoospores possessing a single flagellum, enabling the spores to propel themselves through moist environments and waterways (Briggs et al. 2010). After chytrid has taken up residence on the skin of the amphibian, the zoospores develop into sporangia, which release more zoospores to infect the host. Chytrid zoospores can live for several months in moist, cool environments, but tend to die at temperatures above 28°C after only a few hours (Forrest and Schlaepfer 2011; Rowley and Alford 2013).

Although chytrid has been well studied, examples of amphibians possessing innate chytrid immunity are rare. The canyon tree frog (*Hyla arenicolor*) in Zion National Park (ZNP) in southwestern Utah may possess a behavioral form of chytrid resistance by behaviorally raising its temperature above the critical threshold of the fungus (Eng 2011). We hypothesized that *H. arenicolor* is capable of ridding itself of the fungus using the behavioral adaptation of basking on hot rocks and elevating skin temperatures above the threshold for chytrid survival. Hypothetically, the frogs with recorded skin temperatures above 28°C should have a lower incidence of the fungal pathogen (Woodhams et al. 2003; Richards-Zawacki 2010; Rohr and Raffel 2010; Chatfield and Richards-Zawacki 2011; Forrest and Schlaepfer 2011; Becker et al. 2012; Rowley and Alford 2013).

## Methods

To test the correlation of *H. arenicolor* chytrid infection with skin temperature and population stability, we sampled *H. arenicolor* in ZNP every week from May 24, 2013 to July 12, 2013 (temperatures are usually greater than 28°C by this date). The canyons traversed were The Middle and North Forks of Taylor Creek, The Keyhole and Pine Creek Canyons, Fat Man's Misery, The Subway, Checkerboard Mesa/Many

Pools/Keyhole Pools, and Orderville Canyon. We sampled and handled 10 frogs per canyon/location and recorded the total number of frogs found within the survey area. Predetermined geographical markers were used as visual cues to outline survey areas within each canyon, which varied in length depending on the canyon. Population data for *H. arenicolor* were gathered over last four years by a research team from Dixie State University (Jones et al. 2010).

An infrared thermometer was used to obtain the temperature of most frogs before they were captured. Only frogs that were sitting on rocks in the sun had their temperatures recorded because they were operationally defined as behaviorally thermoregulating their body temperatures. Samples were obtained from sunbathing frogs by wiping sterile swabs in the armpit and pelvic/leg juncture on the ventral side of the frog, where sites of chytrid infection are commonly found (Pessier 2002). We used one sterile swab for each frog and used 25 strokes at each anatomical site. The swab was placed into a dry storage vial and frozen within 6 hours. We sent the samples to the San Diego Zoo Diagnostic Lab, where they were tested for the presence of the fungus using polymerase chain reaction.

## Results

We collected a total of 69 samples from 10 canyons, 48 of which were accompanied with infrared temperature recordings. Previous years lacked temperature recordings to accompany survey data. We therefore used a sample size of 48 for data analysis. The number of samples infected with chytrid for each year starting with 2010 was 11, 8, 13, and 13 (Fig. 1).

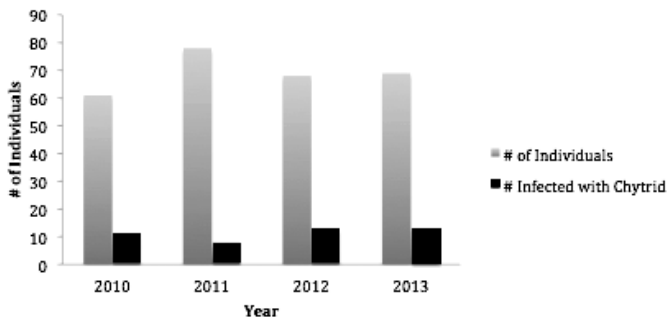


Figure 1. Number of individuals infected and collected 2010-2013.

We compared the number of collected samples from 2010–2012 (combined) and 2013 with the total number of infected individuals within those samples. Using a significance test for proportions, we found that the proportion of infection individuals in the population remained the same ( $z=0.0427$ ,  $p>0.05$ ). We individually compared the year 2012 with our data from 2013 to see whether there was any change over the past year ( $z=0.7417$ ,  $p>0.05$ ). Only 3 of the 13 frogs infected with chytrid had infrared temperatures to accompany them. We therefore did not have sufficient power to run a significance test.

Individual canyon results for all years can be found in Figure 2. Population surveys of all canyons were conducted for all years, including the 2013 data collected by our research team. These surveys counted all frogs seen within the survey area, including the 10 sun-basking frogs within each canyon that were swabbed for chytrid. Population numbers were lowest in 2010 at a total of 225 frogs, which was followed by an increase in 2011 to a total of 352 frogs. Populations were highest in 2012, with a total of 658 frogs seen, before a dip occurred in 2013, with an observed number of 506.

## Discussion

Our results suggested that canyon tree frog populations within ZNP have remained relatively stable over the last four years, despite the presence of the chytrid fungus. Other amphibian populations have exhibited rapid decline after chytrid emergence within the community (Skerratt et al. 2007; Rosa et al. 2013). Population numbers appeared to steadily increase from 2010 to 2012, followed by a slight fall in numbers in 2013. This shift may be due to prevailing weather conditions during surveys, annual drought or humidity within ZNP, or other ecological variables. ZNP is typically an arid environment that is not conducive to chytrid proliferation, and a year with unusually high humidity may alter infection rates. It was not clear how long chytrid fungus has been present within the canyons. The ability of the frog to rid itself of the fungus using behavioral adaptation was inconclusive because our temperature data only includes frogs surveyed in 2013.

However, our study demonstrated two points regarding the ability of the canyon tree frog to rid itself of chytrid infection in ZNP. First, the population of the canyon tree frog has remained relatively stable for at least three years despite the presence of chytrid. Amphibian populations commonly exhibit population declines once this lethal fungus is introduced (Skerratt et al. 2007; Rosa et al. 2013). Second, the presence of chytrid within individual canyons fluctuated from year to year, from being barely present within a single canyon to being

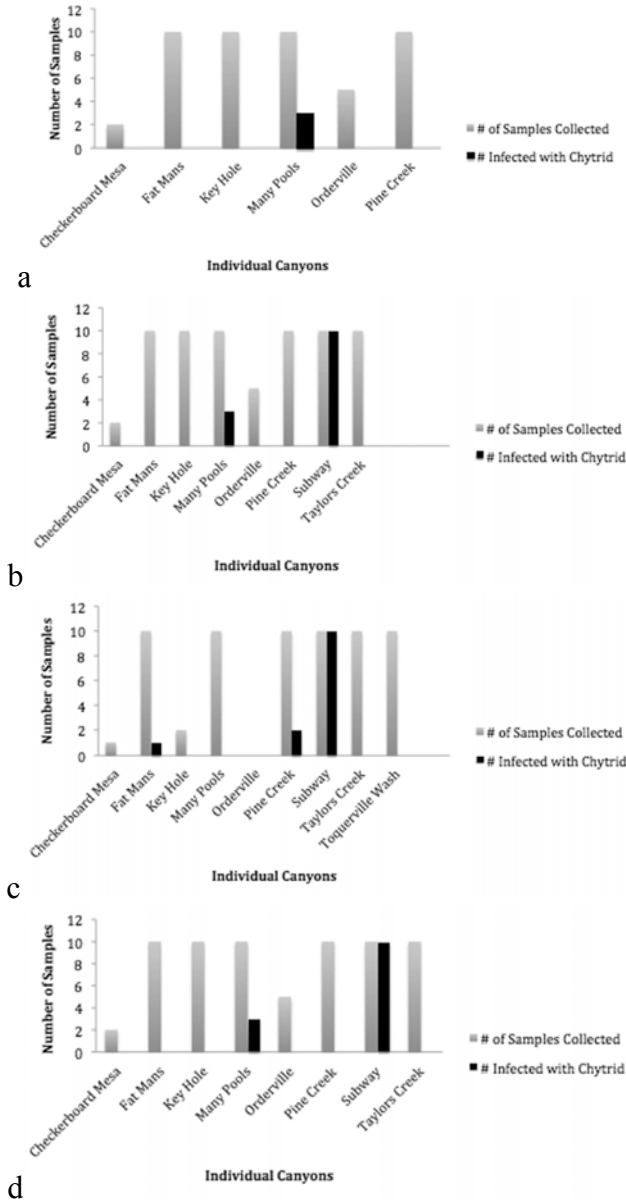


Figure 2. Number of frogs infected with the chytrid fungus in (a) 2010, (b) 2011, (c) 2012, and (d) 2013.

relatively prevalent in multiple canyons (Figure 2). The disappearance of chytrid fungus from a canyon after introduction to the canyon is intriguing. These two points suggest that evidence for the ability of the canyon tree frog to rid itself of the fungus may be present.

The chytrid fungus is unstable at elevated body temperatures, and frogs with body temperatures above 25°C exhibit lower rate of infection (Chatfield and Richards-Zawacki 2011; Forrest and Schlaepfer 2011; Rowley and Alford 2013). Frogs behaviorally thermoregulating within our study areas had recorded temperatures ranging from 25 to 38°C. The frogs may be elevating body temperatures solely to disable the chytrid or possibly for alternate reasons (such as to aid in digestion or reproduction) that coincidentally reduce opportunities for fungal infection (Rowley and Alford 2013). The variation of individuals infected with chytrid is important to note because it causes ambiguity in identifying the plausible causes of amphibian declines, especially at the population level.

Such ambiguity requires further investigation of the chytrid infection and its effect on the canyon tree frog population in the canyons of ZNP. Although immune defense against chytrid has not been researched in the canyon tree frog, one frog species has been shown to elevate its skin temperature to reduce chytrid infection: the Panamanian golden frog (*Atelopus zeteki*) demonstrated thermoregulatory behavior in the wild to decrease chytrid infection (Richards-Zawacki 2010). Another plausible cause of the stable populations of canyon tree frogs within ZNP may be weather-controlled chytrid proliferation (Murray et al. 2013). Chytrid may spread according to prevailing weather conditions, such as increased humidity and rainfall because chytrid is rapidly spread in these conditions (Briggs et al. 2010). The dry conditions within ZNP are not optimal for chytrid proliferation, which may further protect the amphibian populations there. Behavioral selections of habitats might also be influencing infection rates and promote host recovery (Briggs et al. 2010; Hossack et al. 2012). Further studies are needed to provide a clearer picture of whether these external factors are affecting chytrid infection rates within ZNP.

The stable population and presence of chytrid require more research to fully understand the ambiguity between the relationship of the thermoregulatory behavior of the frog and chytrid. Other research could focus on climate variability within the study areas and possible correlations with infection outbreaks.

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# Assessing the Effectiveness of Hybrid Course Design and Student Learning Outcomes in Management and Math Courses

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## Abstract

*This paper examines the role and effectiveness of hybrid, or blended learning, course offerings within the higher education context. Providing a brief review of the growing body of academic literature on e-learning, blended learning, and the effectiveness of the hybrid model, this paper provides a brief look at two distinct hybrid courses: one lower-division college algebra course and one upper-division human resource management course. An assessment rubric and survey assessment questions for hybrid effectiveness will be presented and applied to each course, and the strengths and weaknesses of each will be briefly discussed. Finally, a brief proposal for continued academic research examining hybrid courses and implementation best practices will be offered.*

## Introduction

With more and more pressure being put on institutions of higher education to both provide greater access to programs and reduce costs, more and more universities and colleges have been embracing the role of distance education progress and online courses. While the quality of online courses has continued to improve over the past decade, and while many students do quite well within the online learning environment, opponents of online learning have long argued for the continued need for the face-to-face atmosphere and interactive environment that is important in the learning process for so many students. Within the context of this pedagogical and technology tension, the hybrid course (partially online, partially face-to-face) has been born.

## Overview of Online Learning and Hybrid Courses

There has been a tremendous amount of research in recent years that has examined online teaching and learning. Tallent-Runnels et al. (2006) provided one of the most comprehensive summaries of this body of knowledge, specifically examining course environment, learners' outcomes, learners' characteristics, and institutional and administrative factors. The authors conclude:

... that most of the studies reviewed were descriptive and exploratory, that most online students are nontraditional and Anglo American, and that few universities have written policies, guidelines, or technical support for faculty members or students. Asynchronous communication seemed to facilitate in-depth communication (but not more than in traditional classes), students liked to move at their own pace, learning outcomes appeared to be the same as in traditional courses, and students with prior training in computers were more satisfied with online courses. Continued research is needed to inform learner outcomes, learner characteristics, course environment, and institutional factors related to delivery system variables in order to test learning theories and teaching models inherent in course design (p. 93).

Hybrid courses are defined as “classes in which instruction takes place in a traditional classroom setting augmented by computer-based or online activities which can replace classroom seat time” (Scida and Saury, 2006, p. 518). As Jeffrey R. Young pointed out in his 2002 article in the *Chronicle of Higher Education*, “... a growing number of colleges are experimenting with ‘hybrid’ or ‘blended’ models of teach-

ing that replace some in-person meetings with virtual sessions” (p. A33). Scida and Saury (2006) further argue that hybrid courses “... are becoming more and more the norm in higher education in the United States as earlier predictions of the explosion of completely online courses have not been borne out in practice” (p. 518; see also Farmer 2003; Ijab et al. 2004; Lindsay 2004; Sauers and Walker 2004; Willet 2002). Furthermore, Young (2002) argues that hybrid classes are less controversial among university faculty than offering traditional fully virtual courses and that “... hybrid courses may be a better way than fully online courses to help busy commuter students” (p. A33).

Many proponents of hybrid courses say their main motivation is to improve the educational experience for students and to relieve limited resource pressures on college campuses, pointing to research that demonstrates that using blended learning improves student success rates in learning outcomes and retention (Boyle et al. 2003) and that hybrid courses alleviate campus classroom shortages and enrollment pressures (Young 2002). Chuck Dziuban, director of the Research Initiative for Teaching Effectiveness at the University of Central Florida, says that his office's research shows that student success rates in hybrid courses on the Central Florida campus are “equivalent or slightly superior” to face-to-face courses and that the hybrid courses have lower dropout rates than do fully online courses (Young 2002). Furthermore, Chris Dede, professor of learning technologies at Harvard University's Graduate School of Education, stated, “A strong case is beginning to be made on the basis of research evidence that many students learn better online than face-to-face, and therefore a mixture is the best way. What proportion that mixture should be would vary from course to course” (Young, 2002, p. A34).

Over the past decade, there have been many advances in the technology and pedagogy of hybrid, or blended learning, courses. Moore (2013) and Moore and Kearsley (2011) have looked at the role of blended learning within the distance education landscape, and Staker (2011) examined the role the disruptive innovation of online learning in the world of education. Additionally, Tucker (2012) looked specifically at emerging technologies that are continuing to enhance student-centered classrooms, and Bonk and Graham (2012) examined the recent practices and trends in blended learning from a global perspective. More recently, Adams (2013) examined which blended learning strategy maximized learning outcomes and job impact and found that contextual factors are highly significant in looking at differences across four research groups. Additionally, Akyol and Garrison (2009) and Akyol et al. (2011) emphasized the role of community building and development of a community of inquiry in order to increase effective-

ness and success of online teaching and learning, and Akyol and Garrison (2008) found significant relationships among teaching presence, cognitive presence and social presence, and students' perceived learning and satisfaction in the course.

## **Hybrid Effectiveness Assessment Questions and a Proposed Rubric**

The effectiveness and impact of hybrid courses is an area needing additional ongoing research attention. In a Middle Tennessee State University working paper (Sitter et al. 2014), researchers have identified and validated the survey items listed below for assessing the effectiveness and impact of hybrid courses based on the following areas: (1) Course Content and Design; (2) Course Interaction and Collaboration; (3) Course Assessment; and (4) Student Perceptions. We have adapted these questions (from the original questions designed specifically for MBA hybrid courses) to be applicable to hybrid courses across academic disciplines (we will evaluate our courses based on these questions in the following sections):

### **Hybrid Course Assessment Questions**

#### *Course Content and Design*

1. Online learning allows for the presentation of course content in a logical, sequential manner in ways that facilitate learning.
2. Online content (including reading, research, review, learning new concepts, and assessment) is as demanding as content delivered in traditional face-to-face courses.
3. Technology used for assignment completion (i.e., discussion boards and exams) is easy to use and understand.
4. As a whole, course assignments or assessments support the objectives of the academic program.

#### *Course Interaction and Collaboration*

5. Residency activities were a valuable component in mastering course content.
6. The amount of communication and interaction between student and faculty in a hybrid course was sufficient for effective learning.
7. Quality of instructor response in a hybrid course is appropriate to facilitate learning.

8. Technology-based communication is as effective as face-to-face communication for responding to questions.

### *Course Assessment*

9. Required assignments in a hybrid course encourage critical thinking.
10. Required assignments in a hybrid course encourage the application of knowledge and skills learned in class to current real-life problems.
11. The feedback from instructor on graded assignments in a hybrid course enhances learning.
12. Instructors in a hybrid course clearly communicated the requirements for the successful completion of assignments.
13. Instructor response time to student questions in a hybrid course was appropriate to allow students to complete required assignments in a timely manner.

### *Student Perceptions*

14. Participation in/facilitation of online discussions in a hybrid course is easier than in a traditional face-to-face class setting.
15. Hybrid courses meet the need for flexible access to educational opportunities.
16. I believe that using a hybrid course design is more effective than traditional teaching methods.
17. I prefer hybrid courses to traditional face-to-face courses.
18. I believe that students can make the same grade in a hybrid course as in a traditional face-to-face course.
19. Students can learn the same amount in a hybrid course as in a traditional face-to-face course.

Based on these questions and other research into the effectiveness and impact of hybrid course offerings (see Adams 2013; Akyol and Garrison 2008; Bonk and Graham 2012; Tucker 2012), the following hybrid course assessment rubric was developed (Figure 1). This rubric can be used by faculty and instructional designers to aid in the development of a new hybrid course, as well as to assess the effectiveness and mark areas for improvement in existing hybrid courses. The course elements evaluated include: (1) Instructional Design and Pedagogy; (2) Communication and Feedback; (3) Course Information/Learner Resources; (4) Course Design and Presentation; (5) Assessment and Evaluation; and (6) Technology Integration. One can then identify whether each general element “Needs Improvement,” is “Effective,” or

is “Exemplary,” with sub-points in each area that allow for greater specificity in course element assessment.

	Needs Development	Effective	Exemplary
<b>Instructional Design and Pedagogy</b>	<ul style="list-style-type: none"> <li>The course provides limited opportunities for active student engagement with course content and with peers</li> <li>Course objectives and expectations for students are insufficiently clear or misaligned with the level of the course</li> <li>Transitions and linkages between classroom and online activities are insufficiently developed</li> </ul>	<ul style="list-style-type: none"> <li>The course provides adequate opportunities for active student engagement with course content and with peers</li> <li>Course objectives and expectations for students are adequately explained and appropriate to the level of the course</li> <li>Transitions and linkages between classroom and online activities are consistent throughout the course</li> </ul>	<ul style="list-style-type: none"> <li>The course provides ample opportunities for active student engagement with course content and with peers</li> <li>Course objectives and expectations for students are clearly explained, challenging, and appropriate to the level of the course</li> <li>Transitions and linkages between classroom and online activities are consistently and creatively developed throughout the course</li> </ul>
<b>Communication and Feedback</b>	Course structure permits relatively few opportunities for student/instructor communication	Course structure permits adequate opportunities for student/instructor communication	Course structure permits frequent opportunities for student/instructor communication
<b>Course Information/Learner Resources</b>	Some resource information (e.g., syllabus, course objectives, technical requirements and assistance information), contacts, and links necessary for students are missing	Most resource information (e.g., syllabus, course objectives, technical requirements and assistance information), contacts, and links necessary for students are provided	All resource information (e.g., syllabus, course objectives, technical requirements and assistance information), contacts, and links necessary for students are provided
<b>Course Design and Presentation</b>	<ul style="list-style-type: none"> <li>Some of the tasks, responsibilities, and steps needed to succeed in the course are only partially explained to students</li> <li>Some course areas and pages are well designed, easily located, and easily accessible</li> </ul>	<ul style="list-style-type: none"> <li>Most of the tasks, responsibilities, and steps needed to succeed in the course are clearly and completely explained to students</li> <li>Most course areas and pages are well designed, easily located, and easily accessible</li> </ul>	<ul style="list-style-type: none"> <li>All of the tasks, responsibilities, and steps needed to succeed in the course are clearly and completely explained to students</li> <li>All course areas and pages are well designed, easily located, and easily accessible</li> </ul>
<b>Assessment and Evaluation</b>	Assessment strategies are used to measure content knowledge and skills	Assessment strategies are used frequently to measure content knowledge and skills	Assessment strategies are used frequently, and in multiple formats, to measure content knowledge and skills
<b>Technology Integration</b>	<ul style="list-style-type: none"> <li>The course utilizes a few Canvas features and no other online resources, such as multimedia or web-based tools</li> <li>Course materials accommodate only a limited variety of learning styles</li> </ul>	<ul style="list-style-type: none"> <li>The course utilizes most Canvas features and some other online resources, such as multimedia and web-based tools</li> <li>Course materials accommodate a number of different learning styles</li> </ul>	<ul style="list-style-type: none"> <li>The course utilizes a full range of Canvas features, multimedia, and web-based tools</li> <li>Course materials consistently meet a number of different learning styles</li> </ul>

Figure 1. Proposed hybrid course assessment rubric

## Brief Case 1: A College Algebra Hybrid Course

College Algebra is the general education course required by many majors at the university level. As such, students that are hoping to study in different disciplines often do not show great interest in mathematics and experience a great deal of math anxiety. A hybrid form of the course was developed (based on the following research: Adams, 2013; Akyol and Garrison, 2008; Bonk and Graham, 2012; Tucker, 2012), in part, as a way for students to meet their requirement while helping to reduce their anxiety level.

In this particular College Algebra hybrid course, there are many online requirements to complement and supplement the in-class structure and face-to-face instruction. Before attending a class session on a particular set of mathematical concepts, students are expected to have already completed several online components. First, students are required to watch a video lecture of instruction, typically 20 minutes, covering that particular concept(s). Second, they have a set of practice problems, typically 5–6, that ideally cover each core concept or each possible variation of a given equation/problem that they would encounter in the future. Once this is complete, students are encouraged to begin their online homework assignment and complete as much as they

are able and then come to class with questions prepared. Homework is not submitted until the day after the face-to-face class session, so students are able to complete the assignment after having asked questions and clarified any confusion they may have about the material.

In each face-to-face class session, the instructor provides an overview of the concepts covered and ensures that adequate time and attention is given to particular “trouble” aspects that present common stumbling blocks for students. The instructor then opens the class for questions. Ideally, students would have already completed all of their outside requirements and are prepared with any questions they needed to ask or things they needed clarified to feel confident to complete their assigned problem set. Once questions are answered and the instructor feels reasonably reassured that the students have overcome any major obstacles they may have encountered in their online assignments, the instructor would then facilitate an in-class activity to reinforce the student learning; often this activity takes the form of an open group “quiz” where students discuss and complete problems that would be similar to what they would find on a typical exam. The students work in groups and are encouraged to use their notes, textbooks, and any other resources they need to fully understand and complete the “quiz.” Simultaneously, the instructor provides assistance with the quiz, moving from group to group and answering any questions or helping students through problems that they may find particularly difficult. After class, students are expected to complete their online homework assignment as well as be prepared for the next face-to-face class.

MyMathLab is the main online technology used in this hybrid course design. Students watch their online lectures through MyMathLab, as well as complete and submit their homework assignments. MyMathLab is a great resource to use outside of class because of the many different approaches it uses to assist students to complete assignments. As the students work through their homework, each problem has links to various resources that students can turn to in order to get the immediate help that they need. For example, a given problem may have a link to a similar problem that shows step by step how to complete the problem, a video lecture that discusses the concept as well as a link to the section of the textbook that covers that concept, and a link that will show them how to solve that exact problem as well as a new problem for them to complete to receive credit on their assignment. These helps, along with others, give students the resources they need to have a full understanding of a given concept.

## *College Algebra Formalized Hybrid Course Assessment*

### **Assessment Questions and Answers for Course (adapted from Sitter et al. 2014)<sup>1</sup>:**

#### *Course Content and Design*

1. Online learning allows for the presentation of course content in a logical, sequential manner in ways that facilitate learning: Yes. This particular course involved introduction of material as well as points of inquiry or further critical thinking such that when students came to class, they were well prepared to ask questions, knowing where they needed more instruction. Also, the level of overlap and “spiral learning” of materials helped students to make sequential connections of concepts that may not have been possible using typical face-to-face instruction.
2. Online content (including reading, research, review, learning new concepts, and assessment) is as demanding as content delivered in traditional face-to-face courses: Yes. The videos and reading required at the beginning of each concept, followed by examples presented and then self-guided learning was as demanding as face-to-face instruction. Students were forced to use critical thinking to make connections of concepts on their own as opposed to having an instructor show or make those connections for them.
3. Technology used for assignment completion (i.e., discussion boards and exams) is easy to use and understand: Yes. My-MathLab is an extremely user-friendly online program that is easy to navigate and complete assignments while providing easy-to-access supplemental materials and review resources.
4. As a whole, course assignments or assessments support the objectives of the academic program: Yes. Objectives for this course include not only mathematical concepts, but also overcoming math anxiety levels in typical students and creating patterns of study and inquiry for students to use in their chosen field of study. The course assignments and assessments supported these by thoroughly covering the mathematical concepts of college algebra as well as helping students to learn

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<sup>1</sup> All assessment question responses based on end-of-semester course student evaluation scores and comments, as well as instructor and peer observations.

and to internalize study patterns and that will assist students to be motivated, active participants in their learning experience.

### *Course Interaction and Collaboration*

5. Residency activities were a valuable component in mastering course content: Yes. Students expressed real enjoyment of in-class time instruction and clarification as a real opportunity to further their understanding and fully solidify knowledge and understanding of concepts in their minds.
6. The amount of communication and interaction between student and faculty in a hybrid course was sufficient for effective learning: Yes. When students fully participated and completed their expected activity outside of the classroom in the online portion, the time in class and amount of communication was more than sufficient to provide an effective learning experience for the students.
7. Quality of instructor response in a hybrid course is appropriate to facilitate learning: Yes. Instruction given to students as well as response to student questions or stumbling concepts helped facilitate learning such that students were more able to fully communicate what they had a firm understanding of and what they still needed clarification on.
8. Technology-based communication is as effective as face-to-face communication for responding to questions: Mixed. Students often felt frustrated in having to navigate the online materials for answers to questions when the instructor could provide the needed answer immediately.

### *Course Assessment*

9. Required assignments in a hybrid course encourage critical thinking: Yes. Students felt that the assignments required them to use critical thinking when having to navigate the material covered. Also, being required to begin the learning process of a particular concept on their own—to the point of being able to answer possible exam-like questions—allowed them to fully engage in the learning process.
10. Required assignments in a hybrid course encourage the application of knowledge and skills learned in class to current real-life problems: Yes. The assignments used in MyMathLab included many application problems for students to see the need for knowledge of the subject area in a variety of fields found in real life.

11. The feedback from instructor on graded assignments in a hybrid course enhances learning: Yes. Students felt that the feedback given on assignments helped to clarify points of confusion, flesh out understanding, or fully solidify understanding of particular concepts.
12. Instructors in a hybrid course clearly communicated the requirements for the successful completion of assignments: Yes. While students expressed confusion as to how the assignments fit together to create a whole learning experience in the beginning of the course, they very quickly caught on to the routine and the benefits of each part of the course and its value in contributing to the overall learning experience.
13. Instructor response time to student questions in a hybrid course was appropriate to allow students to complete required assignments in a timely manner: Yes. Students expressed appreciation for feedback given in a timely manner as well as the built-in overlap or “spiral learning” involved in the course, which encouraged better understanding and more critical thinking about particular concept.

### *Student Perceptions*

14. Participation in/facilitation of online discussions in a hybrid course is easier than in a traditional face-to-face class setting: No. Students felt that asking mathematical questions that required formatting in online forums difficult and tedious. They much preferred traditional face-to-face sessions when wanting to have a full discussion of concepts as well as to explore meaning in some of the material.
15. Hybrid courses meet the need for flexible access to educational opportunities: Yes. Students in this class were from varied stages of learning and outside life commitments that required different time tables in their learning. The hybrid course met those needs for individuals to devote their own personal required amount of time and effort to meet the requirements of the course.
16. I believe that using a hybrid course design is more effective than traditional teaching methods: Mixed. Some students really valued the hybrid approach and the flexibility and opportunities it gave them for self-learning and growth. However, students who typically did not take full advantage of the opportunities that the hybrid approach offered them found it to be frustrating and less effective.

17. I prefer hybrid courses to traditional face-to-face courses: Mixed. Students' personalities, personal preferences, and past experiences all played a role in whether or not they preferred the hybrid course over traditional courses or not.
18. I believe that students can make the same grade in a hybrid course as in a traditional face-to-face course: Mixed. While students in this class performed very well and were able to meet the required objectives for the course, there are some students who may have benefited more from a traditional face-to-face course. There were some students whose learning styles and past experiences of learning made them feel that a non-hybrid approach would have been more beneficial to them.
19. Students can learn the same amount in a hybrid course as in a traditional face-to-face course: Mixed. Again, the opinion of the students was dependent upon their personalities, personal preferences, and past experiences in learning environments.

### **Application of Proposed Assessment Rubric and Course Self-Assessment**

- *Instructional Design and Pedagogy:* The overall design of the hybrid course was well thought out and fully covered the required objectives of the course. There could have been more activities/varied ways of instruction—particularly in the beginning—where students could have better seen and appreciated the connections between the outside online assignments and the in-class activities and discussions to fully benefit from the overlap and “spiral learning” techniques.
- *Communication and Feedback:* The course design allowed for regular and effective communication and feedback from the instructor.
- *Course Information/Learner Resources:* The syllabus, in-class information and reminders, and particularly the resources given in MyMathLab were not only sufficient, but probably exceeded that of a traditional face-to-face course.
- *Course Design and Presentation:* The overall design and presentation of the course was well-thought out; however, a more effective or creative way to help students understand and see the benefits of the design and connections between online and in-class instruction would have been helpful.

- *Assessment and Evaluation:* Assessment techniques were implemented regularly and effectively to evaluate the level of student understanding.
- *Technology Integration:* The integration of technology in this course was well done; however, there could have been more creative or even preformatted discussion questions to allow for better online discussion and engagement.
- *Overall Comments:* Overall, elements and sub-elements of this course (based on the developed hybrid assessment rubric) fall into the “Effective” and “Exemplary” categories. While there are many aspects that could be enhanced, the course is very effective in various aspects of its design and implementation.

## **Brief Case 2: An Introductory Human Resources Hybrid Course**

Human resource (HR) management is a core required course for all major students across disciplines within the business school. As such, most students taking the course are not particularly interested in pursuing a career in the HR field but are often seeking to simply fill a needed requirement. For years, this class has been offered in traditional face-to-face sections, condensed weeknight sections, condensed weekend sections, and in online sections; however, a couple of years ago, a hybrid form of the course was also developed (based on the following research: Adams 2013; Akyol and Garrison 2008; Bonk and Graham 2012; Tucker 2012) in an attempt to capitalize on the flexibility and cost-savings benefits of online courses, while also allowing for needed classroom interaction.

In this particular HR management hybrid course, there are many online requirements to complement and supplement the in-class structure and face-to-face instruction. Before attending a class session on a particular set of HR management concepts and principles, students are expected to have already completed several online components. First, students are required to watch a series of short online video lectures or instructional videos covering the topic. Second, students are given a list of assigned readings that are followed by a related short case study write-up that they must do to demonstrate their understanding of the material and its application. Additionally, the students choose between three possible applicable current event articles and questions that relate to the assigned reading and require the students to exercise their critical thinking skills. The short application papers are submitted via the course website each week and are accompanied by an online chat re-

quirement to get students interacting with other students' responses to the case and current event questions. All of this work occurs asynchronously prior to the face-to-face class session when the material is covered in greater depth. Following the face-to-face session, students are then required to submit a weekly learning reflection paper, where they further engage with the material through exploring their unique "a-ha" learning moments and how the particular material applies specifically to them and their experiences (past and present).

In each face-to-face class session, the instructor focuses on certain concepts and principles that need additional explanation and ensures that adequate time and attention is given to questions and confusing aspects of the readings and their learning application. In-class small-group and class discussions are used to provide opportunity for in-depth discussion of core issues (as the students have been required to have done a substantial amount of class preparation related to the material already). Short group activities and classroom learning simulations are also used as appropriate, with the aim of making each face-to-face session an opportunity for rich interaction and student engagement, while also providing clear, applicable, and actionable takeaways for each session. Finally, as mentioned above, after each class, students are expected to complete their weekly learning reflection paper on that week's material and then start the preparation process for the following week's face-to-face class session.

When this hybrid course was first developed, the online learning platform used was Blackboard; however, the class now uses a more instructor and student user-friendly interactive online learning platform called Canvas (which allows for all of the traditional online features of Blackboard, while also allowing for video chats between students and with instructors, dynamic online discussions, connectivity to social media and networking sites, and many other useful online features). Students in this specific hybrid course mostly utilize the online discussion boards, assignment submissions, and file management aspects of Canvas to facilitate their out-of-class asynchronous learning.

## *HR Formalized Hybrid Course Assessment*

### **Assessment Questions and Answers for Course (adapted from Sitter et al. 2014)<sup>2</sup>:**

#### *Course Content and Design*

1. Online learning allows for the presentation of course content in a logical, sequential manner in ways that facilitate learning: Yes, although students sometimes expressed frustration and confusion with the module format and being able to access applicable assignment documents when they couldn't remember which module they were presented in. In this case, it would have been helpful to have both the module format for content delivery, as well as a categorized file page, where they could access any course content.
2. Online content (including reading, research, review, learning new concepts, and assessment) is as demanding as content delivered in traditional face-to-face courses: Yes, in fact students consistently expressed the feeling that the online content was more rigorous and demanding than traditional face-to-face courses.
3. Technology used for assignment completion (i.e., discussion boards and exams) is easy to use and understand: Yes, the students expressed no concerns regarding the technological integration.
4. As a whole, course assignments or assessments support the objectives of the academic program: Yes, all course learning and assessment activities (both in class and online) are directly tied to course and program essential learning objectives.

#### *Course Interaction and Collaboration*

5. Residency activities were a valuable component in mastering course content: Yes, students consistently expressed their satisfaction with in-class session, where we held dynamic group and class discussions, had relevant guest speakers from industry, and participated in other engaging learning activities.
6. The amount of communication and interaction between student and faculty in a hybrid course was sufficient for effective

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<sup>2</sup> All assessment question responses based on end-of-semester course student evaluation scores and comments, as well as instructor and peer observations.

learning: Yes, students consistently expressed satisfaction with course communication and responsiveness of instructor to assignments and course questions.

7. Quality of instructor response in a hybrid course is appropriate to facilitate learning: Yes, the students consistently expressed satisfaction with the quality and quantity of online course interaction and instructor feedback.
8. Technology-based communication is as effective as face-to-face communication for responding to questions: Yes, and in some cases more so, as students could repeatedly refer back to class announcements and assignment descriptions at any time.

### *Course Assessment*

9. Required assignments in a hybrid course encourage critical thinking: Yes, all assignments were application and reflection based, required substantial critical thinking.
10. Required assignments in a hybrid course encourage the application of knowledge and skills learned in class to current real-life problems: Yes, all assignments were application based.
11. The feedback from instructor on graded assignments in a hybrid course enhances learning: Yes, students consistently stated that both the timeliness and quality of assignment feedback was helpful and enhanced their learning.
12. Instructors in a hybrid course clearly communicated the requirements for the successful completion of assignments: Yes, as stated clearly in the syllabus at the beginning of the semester, as well as in assignment descriptions and posted grading rubrics, students always knew what was expected and how to be successful. Some time in class was also devoted to reinforce some of these requirements, expectations, and resources for success.
13. Instructor response time to student questions in a hybrid course was appropriate to allow students to complete required assignments in a timely manner: Yes, students were very satisfied with the timeliness of assignment feedback.

### *Student Perceptions*

14. Participation in/facilitation of online discussions in a hybrid course is easier than in a traditional face-to-face class setting: No. Having meaningful online discussions was the biggest challenge in this hybrid course, and online discussion activities did not approximate the value of in-class discussions.

15. Hybrid courses meet the need for flexible access to educational opportunities: Yes, students consistently expressed satisfaction with hybrid course flexibility.
16. I believe that using a hybrid course design is more effective than traditional teaching methods: Mixed; while students obviously have a mixture of attitudes regarding hybrid course effectiveness, when the course is designed and implemented right, many students see the value. However, a poorly designed/implemented hybrid course is seen as no more valuable or effective than a traditional classroom environment.
17. I prefer hybrid courses to traditional face-to-face courses: Mixed; some students really prefer traditional face-to-face classes, some prefer fully online classes, and some really enjoy the hybrid model.
18. I believe that students can make the same grade in a hybrid course as in a traditional face-to-face course: Mixed; while students were able to perform very well (as with fully online courses), for a student to be successful in this hybrid course they need to stay on top of the weekly modules and assignments. The structure and scaffolding is in place to help all students succeed, but they have to be a bit more self-motivated than in a traditional face-to-face course. For some students, the hybrid model helps them achieve a better grade, while for others the more rigid weekly structure and increased ongoing assignments result in poorer overall course performance.
19. Students can learn the same amount in a hybrid course as in a traditional face-to-face course: Mixed; as with question 18 above, it largely depends on student disposition, learning style, and study habits.

### **Application of Proposed Assessment Rubric and Course Self-Assessment**

- *Instructional Design and Pedagogy:* While the course objectives and expectations for students are very clear and appropriate for the level of the course, transitions and linkages between classroom and online activities could be more creatively developed throughout the course. Additionally, while the course provides ample opportunities for active student engagement with course content, it could be enhanced by having more asynchronous engagement with peers.
- *Communication and Feedback:* The course structure permits frequent opportunities for student/instructor communication.

- *Course Information/Learner Resources:* All resource information (e.g., syllabus, course objectives, technical requirements and assistance information), contacts, and links necessary for students are provided.
- *Course Design and Presentation:* While all of the tasks, responsibilities, and steps needed to succeed in the course are clearly and completely explained to students, the design and accessibility of course areas and pages could be improved.
- *Assessment and Evaluation:* Assessment strategies are used frequently and in multiple formats to measure content knowledge and skills.
- *Technology Integration:* While course materials consistently meet a number of different learning styles, the course could utilize more Canvas features and some other online resources, such as multimedia and web-based tools.
- *Overall Comments:* Overall, elements and sub-elements of this course (based on the developed hybrid assessment rubric) fall into the “Effective” and “Exemplary” categories. While there are many aspects that could be enhanced, the course is very effective in various aspects of its design and implementation.

## **Strengths, Weaknesses, and Practical Recommendations for Future Hybrid Course Implementation**

### *Strengths and Weaknesses of a College Algebra Hybrid Course*

Based on recent research on offering effective hybrid courses (see Adams 2013; Akyol and Garrison 2008; Bonk and Graham 2012; Tucker 2012) and the proposed assessment questions and hybrid rubric, we found that there were several weaknesses to this model of hybrid course for teaching college algebra. First and foremost, this model was assignment intensive. Each student was required to watch the video lecture, complete practice problems, and do a homework assignment as well as a quiz for each section. We felt that this was a significant requirement load for this class, although there are many instructors that feel that this was certainly appropriate for the given credit load. Secondly, we found that students were not always prepared for the in-class instruction with their questions or things that they wished to discuss to make the most of their in-class time with the instructor. We believe that this was due to multiple factors, including students not starting homework before class, not wishing to appear unknowledgeable on a certain

topic, and the early hour at which this particular class was taught (7 am). A strength of this approach was the multiple learning approaches that students were required to take when learning a new concept. This allowed for multiple pedagogical techniques to be used by each student in order for them to have a better understanding of each concept.

### *Strengths and Weaknesses of an Introductory HR Hybrid Course*

As with the college algebra hybrid course (based on recent research on offering effective hybrid courses: Adams 2013; Akyol and Garrison 2008; Bonk and Graham 2012; Tucker 2012; see also the proposed assessment questions and hybrid rubric), the HR management hybrid course is also very assignment intensive. We found that the effectiveness and quality of each weeks' face-to-face sessions was largely dependent on each students' personal preparation, with some students obviously consistently taking the lead in the in-class discussions and activities while other students continued to be more passive (with even a bit of a free rider effect happening at times). A clear strength of this approach is the multiple learning approaches and the requirement for continual reflection, application, and deep learning of the material, rather than focusing on surface-level and more superficial aspects of the content.

### *Practical Recommendations*

Some of the biggest challenges facing the effective implementation of hybrid courses include the difficulties sometimes involved with technology-based communication (particularly when dealing with computationally difficult material, such as math equations) and having meaningful online discussions and participation. It is recommended that future hybrid courses seek to streamline student-to-student and student-instructor communications and create more creative ways to involve students in online discussions (particularly for sometimes technical mathematical discussions), possibly by using preformatted discussion questions. Finally, student attitudes regarding the effectiveness and learning within a hybrid course is mixed and future hybrid courses should systematically assess those attitudes as well as take steps to reduce cognitive barriers to hybrid learning through student instruction and preparation.

## Proposed Future Research on Hybrid Courses

Future research needs to continue to explore the effective use of hybrid courses within the ever-changing landscape of higher education. Such research needs to look in-depth at learning and various stakeholder outcomes of hybrid teaching, as compared directly with a variety of other teaching models (including traditional semester-long face-to-face courses, condensed face-to-face courses, strictly online courses, etc.) across academic disciplines. Much of this research can and may take a comparative case-methodology approach, but where feasible, other rigorous quantitative, qualitative, and mixed-methods approaches should also be utilized.

## Conclusion

In conclusion, it is important to both recognize and embrace that the landscape of higher education is continuing to change. With the continued increase in online and distance education course offerings, including the growing popularity of “MOOCs” (massive open online courses), institutions of higher education need to find more cost-effective and value-added ways to provide reasonably priced, meaningful, and substantial education for its students. The adoption of hybrid courses provides a unique opportunity to bridge the divide but much more research needs to be conducted to demonstrate the utility and sustainability of such an approach. The brief comparative cases provided herein demonstrate that there are indeed both strengths and weaknesses to the hybrid approach and that a one-size-fits-all model will likely not be effective when it is applied to a diverse set of students, across a diverse set of disciplines.

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# Effects of Human Development Misconceptions on Course Achievement by College Type and Gender

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## **Abstract**

*Research on the effect of students' prior subject matter misconceptions as it affects end-of-term grades indicates the predictive nature of such investigations. It is a common belief among educators that students who have fewer subject matter misconceptions will do better in a course than students with more subject matter misconceptions. The purpose of the present study is to identify the amount of correct prior knowledge of lifespan development held by students in psychology courses at both the community college and the university level and to compare this level of knowledge with end-of-term grades by institution type and gender. Five classes on human development were taught by the same instructor at both the community college and the university level during the same term, with a total of 102 undergraduate students. All students answered pre-chapter review questionnaires referring to*

*common human development truths and misconceptions. Pearson's correlation indicates that there is a significant positive correlation between the number of pre-chapter review questions answered correctly over the term and end-of-term class grades ( $p < 0.01$ ). Knowing that misconceptions affect student's end-of-term grades will be helpful to students and educators as they embark on a developmental psychology course.*

A course in human development lifespan fulfills a general education requirement at many universities and colleges throughout the country. These courses are often taught in a psychology class and typically include aspects of the social and emotional development from the first two years of life through late adulthood as well as the physical development of the brain and body from conception to death. Students who select the course often desire to understand their own developmental past, present, and future; yet their preconceptions of the topic are often fraught with many misconceptions about what lifespan development entails and the sequence of changes it involves (McDevitt et al. 2010).

More than 80 years of research has been conducted to identify and address misconceptions as they relate to a number of different psychology courses (Brown 1983; Gardner and Dalsing 1986; Gutman 1979; Kowalski and Taylor 2009; Kuhle et al. 2007; McDevitt et al. 2010; Silvestro 1977; Vaughan 1977). There is also research that indicates that the quantity of misconceptions brought into a classroom may affect how learning is received and may play a role in students' interpretations of the academic concepts presented (Alvermann et al. 1985; Modell et al. 2005; Smith et al. 1993). Additionally, prior studies by Kuhle et al. (2007) as well as Vaughan (1977) argue that students who have fewer subject content misconceptions will do better in a course than students with more subject matter misconceptions. Once identified, knowledge of the number of misconceptions commonly held allows students to discern the limitations of their knowledge about developmental psychology and their risk for performing poorly in the course (Kuhle et al. 2007; Vaughan 1977).

A parallel line of research investigates the commonly held belief that community college and university students differ in a number of ways, including types of students who attend either institution and level of content taught in courses (Blankenship 2010; Chaker 2003; Culpepper 2006), types of faculty that teach at either institution (Hardy and Laanan 2006), as well as faculty/student interactions (Chang 2005). This study attempts to converge these two lines of research and investigates the effect of students' prior human development misconceptions

on end-of-term grades at both the community college and the university level.

Teachers of human development know that students do not enter the classroom as blank slates. Students come with knowledge that may be riddled with inconsistencies and half-truths or is just plain incorrect (Vaughan 1977) that has been accumulated over at least 18 years of observing humans, listening to family members and friends, engaging with popular media, and gleaned information from books or the internet (Gardner and Dalsing 1986).

McDevitt et al. (2010) write that college students hold many distinct beliefs about human development and that "some students may believe that due to a common maturation process people worldwide appear to experience common changes or development as they age. Whereas other students may assume that developmental sequences vary dramatically among individuals depending upon unique experiences such as child-rearing, culture, socio-economic status, etc." (p.533). Taking either or both of these viewpoints may play a role in students' interpretations of academic concepts presented in a lifespan development class.

As a teacher obviously cannot start from scratch when teaching a beginning developmental psychology course, he or she must build upon an already existing foundation of somewhat misinformed lay-psychology. Silvestro (1977) and Struab (2010) both state that the major task for instructors teaching this course is to provide strong content knowledge of developmental psychology as a field of study while at the same time helping students understand that development includes various aspects of physical, cognitive, and social-emotional stages, many of which may not coincide with the previous knowledge students bring into the classroom. Despite a teacher's best efforts to address misconceptions during lectures, discussions, and assignments, students' resistance to correct information could ultimately impact end-of-term grades (Alvermann et al. 1985; Modell et al. 2005; Smith et al. 1993).

A unique opportunity to further the research on this topic presented itself when the author taught several lifespan development courses at both the community college and the university level during the same instructional term. Using pre-chapter review questionnaires supplied by the instructor's manual (Straub 2010), students' beliefs about basic developmental issues were gathered throughout the term, then compared and charted against end-of-term course grades. These pre-chapter review questionnaires contained both correct and incorrect developmental statements. This approach differs from many previous studies, which have focused on gathering students' understanding of

the psychological topic being taught only on the first day of class (Gardner and Dalsing 1986; Kuhle et al. 2007; Vaughan 1977).

The purpose of the present study is to identify the amount of correct prior lifespan development knowledge held by students at both the community college and the university level and to compare this level of knowledge with end-of-term grades, according to institution type and gender. This information would be of interest to developmental psychology instructors teaching at either the community college or the university level and may further the research by revealing to what extent subject matter misconceptions impact students' end-of-term grades, as Alvermann et al. (1985), Modell et al. (2005), and Smith et al. (1993) conclude, while also attempting to identify similarities and differences between these two student populations.

Knowing in advance the level of correct prior subject matter knowledge students bring into the class room may help an instructor know how to best tailor and deliver content information, while additionally identifying those students who may need further assistance in the course. Moreover, knowledge of the number of misconceptions brought by students into the human development lifespan classroom may allow students to discern the limitations of their knowledge about developmental psychology and their risk for performing poorly in the course (Kuhle et al. 2007; Vaughan 1977) and may evoke change and aid in learning as Broughton (2008) asserts.

## **Method**

### *Participants*

Student participants were enrolled in one of five human development lifespan courses taught by the same instructor during the same term. Three courses were taught at a local multi-campus community college in a western mountain state, while the remaining two were taught at a nearby four-year university. The community college and the university are located in abutting counties; the university campus is located approximately 30 miles south of the community college.

The classes participating in this study ranged in size from 15 to 26 students ( $M = 20.4$ ,  $SD = 4.13$ ) for a total  $N$  of 119 students. Students were pursuing a variety of majors and completing the lifespan course in fulfillment of college core curriculum requirements.

Ten of the community college students were dropped from the study as they did not sign the necessary consent form. Seven students (three from the community college and four from the university) were dropped because they answered fewer than 50% of the questions on the

pre-chapter review questionnaires, leaving a total of N of 102 students taking part in this study.

Of this total, 65 students were enrolled at the community college, with the remaining 37 students being enrolled at the university. The majority of students (64%) were women. Most of the students (46%) were first-year college students, 43 percent were sophomores, while the remaining 11 percent were upper-division students (juniors or seniors). In an effort to show the similarity of the students, college standing, age, and gender were recorded and are shown in Tables 1 and 2 below.

<b>Table 1. Distribution of Participants by Institution</b>			
	<b>Community College (N=65)</b>	<b>University (N=37)</b>	<b>Total (N=102)</b>
<b>Gender</b>			
Male	23	14	37
Female	42	23	65
<b>College Standing</b>			
Freshman	38	9	47
Sophomore	27	17	44
Junior	0	4	4
Senior	0	7	7

Some students at the community college reported their college-level standing as junior or senior, but school records could not substantiate this information; therefore, it was impossible to know with certainty if there were higher-level students in the community college classes who were a part of this study. In an effort to mitigate this problem, school records only were used to record community college students' college-level standing, therefore, a comparison between junior/senior students is not possible for this study.

Students ranged in age from 18 to 56 years ( $M = 25.06$  years,  $SD = 7.38$  years). Male students were slightly younger than female students, with average male age being 24.74 ( $SD = 5.74$ ), while average age for female students was 25.39 ( $SD = 8.15$ ) (Table 2).

As can be seen, the community college students were slightly younger than the university students. Additionally, there was no profound demographic difference between students of these two higher-learning types as both institutions share students from surrounding residential locations.

<b>Table 2. Mean Age of Participants by Gender and Institution Type</b>				
<b>Institution</b>	<b>N</b>	<b>Males</b>	<b>Females</b>	<b>Average</b>
Comm. College	65	23	24.15	23.57
University	38	26.47	26.63	26.55
Average		24.74	25.39	25.06

### *Procedures*

All classes were full-term daytime classes except one university class, which was a second block night class. Each class was taught by the same instructor using Berger’s (2010) text, *Invitation to the Life Span*. The classes mirrored each other in every way; all students were given the same lecture, engaged in the same in-class activities, completed the same homework assignments, and were administered the same exams. Grading rubrics for all assignments and exams were also identical.

The basic teaching strategy employed in all classes was one of class lecture with strong encouragement for discussion. Lectures covered items by addressing the scientific understanding of the concept, often supplemented with films, group activities, self- reflection, and assignments that took the students out into the community. McDevitt et al. (2010) state that “worthwhile instructional strategies include those that foster active participation, present concrete and engaging activities, create disequilibrium in thinking, challenge non-productive ideas, and support self-reflection” (p. 533). They further state that “these tactics may be particularly powerful when instructors become aware of students’ typical preconceived ideas ahead of time and then challenge these misconceptions during lectures, discussions, and assignments” (p. 533). This approach is also supported by Vaughan (1977) and is the model for this study.

Participants were advised of the study on the first day of class. It was explained to students that pre-chapter review questionnaires would be administered throughout the term (prior to introducing substantive content knowledge) and that answering or not answering these questionnaires would have no impact on students’ end-of-term grades. Consent forms were then administered, and students were given the opportunity to opt out if they so desired.

These pre-chapter review questionnaires consisted of 10-14 short true/false statements, depending on the chapter, and included both correct and incorrect subject matter knowledge. Answering these questionnaires prior to instruction allowed participating students to report

their correct and incorrect subject matter knowledge, which could then be specifically addressed during the class. Students were able to complete each questionnaire in approximately five minutes. Once the questionnaires were completed and handed in, instruction on the chapter commenced.

Sixteen pre-chapter review questionnaires were administered throughout the term for a total of 166 questions per student. Examples of the types of questions asked in a pre-chapter review questionnaire can be found in Appendix A. No extra credit or remuneration of any type was offered to students participating in this study.

### *Research design*

The pre-chapter review questionnaires were scored for each student by counting the number of correctly marked statements. Scores ranged from 86 to 92%, with a mean of 88.25%, median of 90.5%, and standard deviation of 2.63. Because the samples are not equal size (community college  $N=65$  and university  $N=38$ ) and expectations of results were tentative, two-tailed  $t$  tests were used with  $p < 0.05$  as the criterion for determining significance of findings. Pearson's correlation coefficient ( $p < 0.05$ ) was used when analyzing possible correlations between the number of items answered correctly on pre-chapter review questionnaires and end-of-term grades.

### **Results**

The initial analysis of the data examined the overall number of correct items answered on the pre-chapter review questionnaires and performance in the course as indicated by end-of-term grades. Students' grades reflect their performance on exams, quizzes, and course assignments. A secondary analysis of data was conducted following the outline above with college-level standing and institution type included. A final analysis was then conducted that introduced gender into the mix. The results reveal interesting differences between the community college and university students.

Of the 166 total pre-chapter review questions administered to each student over the term, on average, students answered 137.5 of those questions ( $SD = 15.75$ ). This number reflects that, for the most part, each student answered all questions on the questionnaires, leaving only 1.78 questions per chapter unanswered. This small number of unanswered questions does not appear to have a substantial impact on the results of this study.

The relationship between the overall number of correct items answered on the pre-chapter review questionnaires throughout the course

and student performance, as indicated by end-of-term grades, was then analyzed (with university upper-division students ( $N=11$ ) removed for a clearer look at comparable populations). The Pearson's correlation indicates that there is a significant positive correlation between the number of pre-chapter review questions answered correctly during the course and end-of-term class grades,  $r$  (102 students) = .38,  $p < 0.01$  2-tailed.

The resulting correlations are displayed graphically in Figure 1. The number of pre-chapter review questions answered correctly over the term does appear to be an indicator of how well students will perform in the course in general.

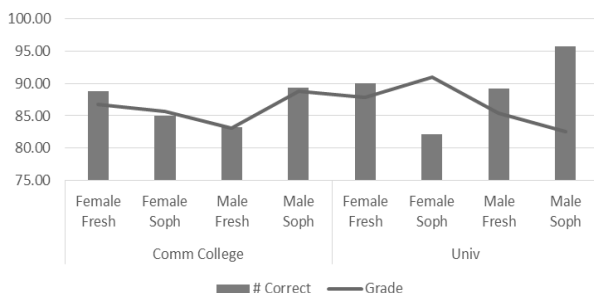


Figure 1. Relationship between the overall number of correct items answered on the pre-chapter review questionnaire and performance in the course.

Next, a comparison of end-of-term grades by institution was conducted. Again, significant results were found. The overall mean end-of-term grade for all students was 87.30/100 ( $Mdn = 88.71$ ,  $SD = 9.01$ ,  $range = 63.09$ -98.98). The average community college students' grade at the end of the term was 85.98/100 (lower than the overall student average), while the average end-of-term grade for university students' was 89.60 (above the overall student average) indicating that, in general, the university students out-performed their community college peers. This difference was found to be significant,  $t_{(100)} = -1.96$ ,  $p < 0.05$ ,  $CI_{.95} -7.26$ , .03, Cohen's  $d = .42$  (Table 3).

A third analysis of the data introduced gender into the mix to further tease out any differences within each college group and between college types. Again, a significant difference was found. Overall, female students' grades between the institutions averaged 88.84/100 (above the overall student average of 87.30). The community college female students, overall, earned 86.52% of the points possible for the course, while the university female students, on average, earned

**Table 3. Distribution of End-of-term Grades**

College Type (N)	Mean±SD	P	95% CI	Eff. Size
CC (65)	85.98± 9.93	-	-	-
Univ (37)	89.60± 6.81	-	-	-
Total (102) T = -1.96/df =100	87.79± 8.37	0.05	-7.26, .03	0.42
CC ♀ (42)	86.52± 10.1	-	-	-
Univ ♀ (23)	91.17± 5.10	-	-	-
Total (65) T = -2.06/df =63	88.84± 7.60	0.04	-9.15, .14	0.58
CC ♂ Fr (13)	83.03± 9.60	-	-	-
Univ ♀-So (13)	90.97± 5.88	-	-	-
Total (26) T = -2.54/df =24	86.99± 7.74	0.01	-14.39, 1.49	0.99
Univ ♂-So (4)	82.60± 9.07	-	-	-
Univ ♀-So (13)	90.97± 5.88	-	-	-
Total (17) T = 2.20/df =15	86.78± 7.47	0.04	.27, 16.46	1.09

CI = Confidence Interval, CC = Community College, Univ = University, Fr = Freshmen, So = Sophomores

91.17% of points possible. This difference was significant,  $t_{(63)} = -2.06$ ,  $p < 0.04$ ,  $CI_{.95}$ , -9.15, .14,  $d$  (.58). Pearson's  $r$  (65 students) = .45,  $p < 0.01$  2-tailed indicates a significant correlation between being female and end-of-term grades (Table 3).

Other comparisons were investigated between institutions, college-level standing, and gender. Many of those comparisons did not result in significant findings; however, a few did stand out and are shown in Table 3 above. Specifically, a significant difference was found when comparing the average end-of-term grades between community college male freshmen and university female sophomores. The community college first-term males earned an average end-of-term grade of 83.03, yet the university female sophomores earned a high end-of-term grade of 90.97. This difference was significant,  $t_{(24)} = -2.54$ ,  $p < 0.01$ ,  $CI_{.95}$ , -14.39, 1.49,  $d$  (.99).

Furthermore, a significant difference was identified when comparing end-of-term grades for university sophomores (male/female). The university male sophomores earned, on average 82.60/100 end-of-term grade (below the overall student average of 87.30), while the university female sophomores earned 90.97 percent of points possible. This dif-

ference was found to be significant,  $t_{(15)} = 2.20$ ,  $p < 0.04$ ,  $CI_{.95}$ , .27, 16.47 with a Cohen's effect size of  $d = 1.09$ .

## Discussion

The purpose of this study was to identify the amount of prior subject matter knowledge brought into the lifespan development class by students at both the community college and the university level and to compare this level of prior knowledge to end-of-term grades by institution type and gender. As it is commonly understood among educators that correct prior beliefs provide a foundation for information that facilitates learning, while incorrect prior beliefs may hamper learning (Kuhle et al. 2007; Vaughan 1977), one would expect that a student giving a higher number of correct answers on pre-chapter review questionnaires in the class would also obtain a higher end-of-term grade in the course. These expectations appear to be in line with the results of this study.

A second item of note is that university students consistently outperformed their community college peers in the course. Grades on assignments, quizzes, and exams were higher overall for this group of students. A review of course performance does not reflect a large difference in attendance during class or missed tests between these two groups. One possible explanation could be that the lectures act as an organizing tool, helping students to first activate their prior, incorrect knowledge and then helping them to replace that knowledge with a more correct version as claimed by Straub (2010), but if that was the case it is expected that this would also carry over to community college students as well (evidence of this was not looked for in this study). Another possible explanation could be that the community college students may be more resistant to changing previously held misconceptions than university students as alluded to by Peters (2013) or that community college students' readiness for learning may be different than that of students attending a university setting as discussed by Millar (2011). Neither of these possible scenarios were investigated in this study and cannot be held up as definitive explanations for the differences seen in this populations' performance. These are questions that require further investigation and cannot be answered by this study.

An additional explanation could be the quantity of outside responsibilities required of the students at the different institution types. For example, the community college students often stated in class that they held full-time jobs and were raising young families while attending college. These added responsibilities did not appear to be as prevalent among the university students who took part in this study. According to

Hawkins et al. (2005) undergraduate student full-time employment and home life environmental factors (Campagna 2013) may have a negative impact on academic achievement in a variety of ways, including detracting from the reservoir of energy and time necessary for content mastery. This factor may have affected end-of-term grades for this group.

A third item of interest is the difference found between the male and female students' end-of-term grades. Although male students not only answered more questions on the pre-chapter review questionnaires and got more of those answers correct (53% male vs 52% correct female), male students did not earn a higher final end-of-term grade than their female peers. It is possible that the sheer increase of overall number of questions answered by the male students could explain why they received a higher percentage of correct answers, while, in reality, male students may not actually possess more prior subject matter knowledge of developmental truths or myths than female students do. The male students may simply have been more willing to "guess" at the answers to questions they did not know, realizing a 50/50 chance of getting the answer correct, as answer options were true or false only.

Another possible reason for this difference could be that females have a higher stake in learning and understanding human development, since they are the ones who will ultimately give birth and are more likely to become primary caregivers for future children, thus making them more prone to be willing to change any incorrect human development knowledge they may bring into the classroom. Although this explanation could explain the differences found between the female and male students' end-of-term grades, it would not carry over to explain the differences in end-of-term grades found between the university and community college female students.

Since everything we learn is permanently stored in the mind, although sometimes particular details are not accessible, there must be some other reason for the differences found between these students as it is unlikely that instructor skill or course material accounts for these differences (as they did not change between courses). Unfortunately, many of the differences found between students among both institution type and gender cannot be explained by this study. There are many gaps in the knowledge, and identifying these gaps is valuable because instructors of developmental psychology may benefit from access to data on the link between the amount of misinformation students bring into the development psychology classroom and how these misconceptions might affect end-of-term grades.

Although many interesting elements surfaced in the study, some limitations must be noted. First, it could not be confirmed that the psychometric properties of the questionnaires provided in the instructor's

manual had been the subject of evaluation; therefore, definitive reliance on these questionnaires for accurate and useful information cannot be assumed. Secondly, because of data limitations, the researcher was unable to determine whether students had taken other psychology or human maturation courses in the past, or how many students may have been parents themselves, either of which may have affected the number of correct answers given by students on the pre-chapter review questionnaires. Additionally, it must be noted that the sample of students utilized for this study was small (102*n* overall) and that number became even smaller when the students were categorized into subgroups delineated by class level standing.

Lastly, there is the question of vocabulary. It is possible that some of the terms used in the questionnaires may have been too technical for beginning developmental students to understand, having instead only heard of various terms in common everyday language. Also, providing students no answer option other than true or false poses a threat as having only true or false answer options forces opinions on each item, even if the student has no opinion or no strong opinion related to the statement, or the student may feel that the item is not completely true or false, thus leaving the student with no other avenue than to leave the question blank (Gardner and Dalsing 1986). Furthermore, students may have been on guard when answering the questionnaires and may have avoided answering in ways that they personally preferred in favor of ways they felt the instructor was perceived to prefer (Brown 1983; Gardner and Dalsing 1986).

Future research on this topic is advised and could more deeply explore the degree to which holding erroneous prior subject matter knowledge may interfere with the acquisition of valid information. There would also be value in research that explored whether various cognitive styles held by students are more open to change.

Despite the limitations, it appears that there continues to be value in studying the amount of prior subject matter misconceptions held by undergraduates, including those who enroll in a human development lifespan course. Prior studies (Kuhle et al. 2007; Vaughan 1977) argue that it makes sense to predict that students who have fewer subject matter misconceptions will do better in a course than students with more subject matter misconceptions. Additionally, once identified, a review of the misconceptions commonly held by students also allows students to discern the limitations of their knowledge, which may reveal their risk for performing poorly in the course (Kuhle et al. 2007; Vaughan 1977). Furthermore, the level of misconceptions brought into a classroom may affect how learning is received and may play a role in students' interpretations of the academic concepts presented (Al-

vermann et al. 1985; Modell et al. 2005; Smith et al. 1993). Thus, identifying prior subject matter misconceptions and then addressing the factors that influence meaningful change (i.e., through course lecture, assignments, and/or exams) is critical if students are to relinquish popular notions of human development and obtain a more scientifically supported understanding of developmental psychology. All of which may affect students' performance in a lifespan development class and is of benefit to those teaching this course as well as to those students taking the course in the future.

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## **Appendix A. Examples of the types of questions asked in the pre-chapter review questionnaires**

From *Instructor's Resources to Accompany Invitation to the Life Span* by Straub (2010).

- |   |   |  |
|---|---|--|
| T | F | The newest theories of development stress the ongoing interaction between the physical and emotional being and environmental forces. |
| T | F | All the genes a person has show up as observable characteristics.  |
| T | F | All healthy infants develop the same motor skills in the same sequence.  |
| T | F | Infant fear, as expressed in stranger wariness, signals abnormal development.  |

- T     F     A 3-year-old is likely to believe that the same amount of ice cream is actually more when it is transferred from a large bowl to a small bowl.
- T     F     The basic cognitive processing capacity of schoolchildren does not differ greatly from that of preschoolers.
- T     F     Children's ability to cope with stress may depend on their resilience when dealing with difficult situations.
- T     F     Although the sequence of puberty is variable, the age of onset is not.
- T     F     Thinking about committing suicide is actually quite rare among high school students.
- T     F     Physical strength, such as that required to lift a heavy load, peaks at age 30.
- T     F     The average level of testosterone in men declines markedly during adulthood.
- T     F     Individual differences in intelligence are "fixed" in that they remain roughly the same over the lifespan.
- T     F     By about age 30, several personality traits stabilize and remain so throughout adulthood.
- T     F     Late adulthood is often associated with a narrowing of interests and an exclusive focus on the self.
- T     F     Developmentalists agree that in old age, the individual and society mutually withdraw from each other.

# The Volition of Intelligence

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## Abstract

*Computer “intelligence,” or artificial intelligence, appears to be making increasing inroads, as evidenced by computers' increasing influence on our lives and by successes in competitions between humans and computers. Despite these advances, computers continue in merely subservient roles, never exhibiting the ability to truly choose for themselves. In this paper, we explore this question of volition. We argue against Turing's test as a means of showing intelligence because it fails to test for volition. Gödel's theorem is used as an example of the result of human volition, and computer's lack of it, and we discuss the theorem in response to Hofstadter's and Penrose's views. We speculate on the possibility that computers may someday be capable of their own volition, and contemplate the risks of the possibility.*

## Prologue

“Design flaw!” was the conclusion of the NTSB following the fiery Mach 5 mid-air explosion of the virgin public flight of GargantuAir 7000. Accusing attention turned to the aerospace design firm McDermot & Frankl, who quickly shifted the blame to the Watson

Mark VI computer. “The computer —we call him Sherlock, you know, our little attempt at humor —volunteered to do the airframe design work,” said engineer McDermot. “We were swamped with propulsion details and glad to have him step up to help. He contacted us, and we were glad, at the time. Sherlock was, you know, a fully licensed professional engineer. Did quite well on the board exams.” The public screamed for the programmer. But Wilford Taylor, Sherlock’s principal software engineer, pointed again at the computer. “He was a legally recognized independent mental entity,” he said. “I had nothing to do with him going into aerospace engineering. It is something he chose to do long after I configured him. He studied engineering, passed the boards, applied for the position —I had nothing to do with it!” For the public looking for someone to pin the blame on, discontent is running high. “It doesn’t seem like just pulling the plug on this machine is justice for those guys on the plane, ya know,” said Joe Bertolini, a member of the “Humans for Humans” organization. “He don’t know nothin’ about how we’z got families. What’s it to him if some humans get blown up? He needs to suffer too, the way I see it.” Contributor “Anonymous” posting on the HfH website said, “I don’t think it was an accident. You think these computers aren’t out to get us? I think we should shut them all down.” Meanwhile, the Watson Mark VI computer refuses to comment, either via voice link or old-fashioned keyboard interaction.

## Introduction

On February 14 and 15, 2011, the *Jeopardy!* TV quiz show match was broadcast, in which the computer system named Watson was pitted against Ken Jennings and Brad Rutter, two top *Jeopardy!* players.<sup>1</sup> The first match ended with the computer Watson in the lead with \$35,734, vs. Rutter in second place at \$10,400 and Jennings with \$4800. The second match ended with another victory for Watson, who won with \$77,147, while Jennings came in second at \$24,000 and Rutter at \$21,600.<sup>2</sup> *Jeopardy!* questions involve broad-ranging topics, puns, allusions, metaphors, and irony, all given in natural English. (Watson was provided with the questions electronically, so it did not have to understand naturally spoken speech. That was not part of the contest.) Success at the game depends on being quick to the buzzer and often

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<sup>1</sup> Ken Jennings holds the record for the longest winning streak on *Jeopardy!*, having won 74 *Jeopardy!* games in a row. Brad Rutter is biggest all-time money winner on *Jeopardy!*. (Wikipedia, “Ken Jennings” and “Brad Rutter,” recovered 27 Dec., 2013.)

<sup>2</sup> Stephen Baker, *Final Jeopardy!*, Houghton Mifflin Harcourt 2011.

depends on finding, and skillfully wagering on, *Double Jeopardy!* questions.<sup>3</sup> Watson's victory in *Jeopardy!* has been viewed as a watershed event in the progress towards strong artificial intelligence (AI). "The viewpoint of strong AI ... maintains that a 'mind' finds its existence through the embodiment of a sufficiently complex algorithm, as this algorithm is acted out by some objects of the physical world. It is not supposed to matter what actual objects these are. Nerve signals, electric currents along wires, cogs, pulleys, or water pipes would do equally well. The algorithm itself is considered to be all-important."<sup>4</sup> Under strong AI, in fact, machines already have a measure of true intelligence. The strong AI advocates insist that intelligence does not depend on the physical medium, so that "true intelligence" will be possible on a computer.<sup>5</sup> The strongest such advocates go so far as to

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<sup>3</sup> "Watson received the clues as electronic texts at the same moment they were made visible to the human players. It would then parse the clues into different keywords and sentence fragments in order to find statistically related phrases. Watson's main innovation was not in the creation of a new algorithm for this operation but rather its ability to quickly execute thousands of proven language analysis algorithms simultaneously to find the correct answer. The more algorithms that find the same answer independently the more likely Watson is to be correct." (Wikipedia, "Watson," downloaded February 24, 2014.)

<sup>4</sup> R. Penrose, *The Emperor's New Mind*, Penguin Books, 1991, p. 429. This book will be referred to hereafter as "ENM." Strong AI was also defined in Searle, "Minds, Brains, and Programs," in *The Behavioral and Brain Sciences*, v. 3, Cambridge University Press, 1980. Page references come from the edited collection D. R. Hofstadter and D. C. Dennett, *The Mind's I*, Basic Books, 1981, Chapter 22. His book will be referred to hereafter as TMI. Searle is writing in opposition to the possibility of strong AI: "[A]ccording to strong AI, the computer is not merely a tool in the study of the mind; rather, the appropriately programmed computer really *is* a mind, in the sense that computers given the right programs can be literally said to *understand* and have other cognitive states. In strong AI, because the programmed computer has cognitive states, the programs are not mere tools that enable us to test psychological explanations; rather, the programs are themselves the explanations." TMI, p. 353

<sup>5</sup> The independence of the physical substrate and the intelligence it bears that is a theme of strong AI is described as follows: "Some philosophers see our inner lights, our 'I's,' our humanity, our souls, as emanating from the nature of the substrate itself—that is, from the organic chemistry of carbon. I find that a most peculiar tree on which to hang the bauble of consciousness. Basically, this is a mystical refrain that explains nothing. Why should the chemistry of carbon have some magical property entirely unlike that of any other substance? And what *is* that magical property? And how does it make us into conscious beings? ... Doesn't any organization or pattern play any role here? Surely it does. And if it does, why couldn't it play the *whole* role." D.R. Hofstadter, *I Am a Strange Loop*, Basic Books, 2007, p. 194. This book will be referred to hereafter as "SL." Strong AI takes the latter viewpoint: organization and pattern take the whole role.

insist that in its own tiny way, even a conventional home thermostat demonstrates a measure of intelligence as it adjusts the temperature.<sup>6</sup>

Watson's remarkable performance raises the question: Could it be that — after decades of research and several false starts<sup>7</sup> — the ultimate goals of strong AI are almost within reach? Despite admiration for the performance of Watson and its human creators, I take the position here that AI lacks a key component of human intelligence, which I will here call *volition*: the ability of an intelligent agent to choose what it will think about and how it will think about it. As I discuss here, computers, even those sporting the latest “AI,” are still things that are acted upon and not things that act for themselves.<sup>8</sup> Furthermore, without this volition, or will or agency, a computer is not thinking in the sense that agents having volition do. This paper also examines the question of whether computers *should* be given volition, if the technical possibility ever arises. As an engineer, the question then emerges for me: is it possible to instill an inanimate object with volition?

## Turing and His Test

When computers actually appeared, it was inevitable for newly fledged computer scientists to wonder whether the power in these incipient computers would enable an assault on that apparently uniquely human attribute of intelligence. Alan Turing, who was instrumental in the development of computers for cryptological analysis during World War II, explored machine intelligence in his paper “Computing Machinery and Intelligence,” published in 1950.<sup>9</sup> Turing boldly opens his paper with, “I propose to consider the question, ‘Can machines think?’” Rather than describing exactly how a thinking machine might be constructed — he seemed to consider it a foregone conclusion that it would happen, and probably soon — he describes a game he called the imitation game, now called the Turing test, for determining whether a machine can think. The Turing test is modified from an imitation game

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<sup>6</sup> “Machines as simple as thermostats can be said to have beliefs, and having beliefs seems to be a characteristic of most machines capable of problem solving performance,” Quoted from McCarthy 1979 in Searle, p. 361 of TMI.

<sup>7</sup> A history of the development of AI research is P. McCorduck, *Machines Who Think*, A.K. Peters, LTD, 2004.

<sup>8</sup> The allusion is to *The Book of Mormon*, 2 Ne 2:14. Lehi has just discussed the law of opposition, without the choices made possible by which “it” must have been created for a thing of naught, wherefore there would have been no *purpose* in the end of its creation. (2 Ne 2:12). It seems that the antecedent of “it” is the “compound in one,” which has no alternatives available to it.

<sup>9</sup> A. Turing, “Computing Machinery and Intelligence” in *Mind*, v. LIX, no. 236, 1950.

that involves three people: an interrogator, a man, and a woman. By means of written questions (to avoid a bias based on voice), the interrogator attempts to determine which of the participants is the woman and which is the man. By their answers, the man and the woman attempt to cause the interrogator to misidentify their gender. In Turing's modification of this imitation game, the test involves three participants: a human (A), a computer (B), and another human, the interrogator (C). The interrogator attempts to determine, by a series of questions put to either (A) or (B), which is the human and which is the computer. To overcome a human tendency to judge based on appearance or sound, Turing proposes that the conversation take place over a teleprinter. (These days, communication via texting or email would be an appropriate substitute.) In Turing's modified imitation game, the computer attempts to answer questions posed to it so as to appear human, and the human answers questions so as to appear computer. Turing proposed interpreting the results as follows:

Will the interrogator decide wrongly [incorrectly identifying the computer as the human] as often when the game is played like this [with a computer] as he does when the game is played between a man and a woman?

Turing proposes his imitation game as a proxy for the question "Can a machine think?" He was so optimistic about the eventual capabilities of computers that he stated, "I believe that in about fifty years' time [which would have been 2000] it will be possible to program computers, with a storage capacity of about  $10^9$ , to make them play the imitation game so well that an average interrogator will not have more than 70 percent chance of making the right identification after five minutes of questioning." He was right about the storage capacity (storage of multiple gigabytes of data is now commonplace), but like many after him, he underestimated the difficulty of his test.<sup>10</sup>

At first blush, the Turing test seems like a reasonable approach to determine whether a machine is intelligent. After all, it is through conversation that we often form an opinion about the intelligence of others. If it is the interrogator who wants to determine whether a machine is

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<sup>10</sup> Other AI pioneers have been similarly overoptimistic. In 1965 Herbert Simon predicted that "machines will be capable, within twenty years, of doing any work a man can do" (*The Shape of Automation for Men and Management*, Harper & Row, 1965) and Marvin Minsky agreed, writing in 1967 that "within a generation ... the problem of creating 'artificial intelligence' will substantially be solved" (*Computation: Finite and Infinite Machines*, Prentice-Hall, 1967.)

intelligent, he, like any scientist, should perform the investigation and determine for himself. There is a general similarity between a Turing test and the *Jeopardy!* match with Watson. Both have an element of a contest and both allow for wide-ranging topics of conversation, with the computer interpreting the question and providing an appropriate answer. The fame of the Turing test contributed to the excitement generated by the *Jeopardy!* match.

On further reflection, however, the Turing test seems limited and stilted as a means of exploring the question “Can machines think?”<sup>11</sup> In his paper, Turing anticipated some objections and dealt with them. But the objections he dealt with were with the possibility of thinking machines, not with the proxy contest he proposes to determine whether the machines are thinking. For example, he discussed briefly what he called “Lady Lovelace’s Objection,” that computers do not originate, and do only what they are ordered to do. Turing’s response is first that he has often been surprised by the results produced by computers (when they were doing what they were asked to do). This surprise often comes to those who work with computers. It is, in fact, one of the great joys of programming to tell a computer to do something and see that it works surprisingly better than expected, or that it has unearthed some bit of Platonic reality. This has nothing to do with creative ability on the part of the computer, only its ability to accurately and quickly do our bidding. Turing ends his defense against the Lady Lovelace objection as follows:

The view that machines cannot give rise to surprises is due, I believe, to a fallacy to which philosophers and mathematicians are particularly subject. This is the assumption that as soon as a fact is presented to a mind all consequences of that fact spring into the mind simultaneously with it. It is a very useful assumption under many circumstances, but one too easily forgets that it is false. A natural consequence of doing so is that one then assumes that there is no virtue in the mere working out of consequences from data and general principles.

His point is that surprises may appear in working out of the consequences of a presentation of fact. This is certainly true, especially

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<sup>11</sup> Since 1991, there has been an annual competition for practical Turing tests. It has been criticized for deflecting AI research from core topics. “The first contest was won by a mindless program with no identifiable intelligence that managed to fool naive interrogators into making the wrong identification... The winner won, in part, because it was able to imitate human typing errors.” (Wikipedia, “Turing Test,” downloaded Dec. 27, 2013)

when one takes the Platonic view that the consequences were, in some sense, pre-existent with the premises, and that the computation (or any fundamental mathematical research of any sort) simply uncovers what lay hidden there. But Lady Lovelace's objection still remains: something must, to use his language, "present a fact" to a mind and make the choice about what to compute about. The presentation and choices were brushed aside.

But, to return to objections to the Turing test itself, there are many objections that might be raised. In the first place, the results subjectively depend on the skill of the interrogator. A less skilled (or biased) interrogator might incorrectly confuse the computer with a human, where a more skilled interrogator would not. Turing himself concedes this possibility when he writes of his "average investigator" and "70 percent chance of making the right determination." The test also relies on the skill of the other human involved.<sup>12</sup> A human skilled in answering like a computer who is attempting to answer like a human could confuse the interrogator, who might then miss the intelligence in the computer.

Another objection is that the basis of the test is deception. Is the best intelligence to be perceived in those who are most skilled at deception? An argument might be made that deception has survival value (for example, the mimicry of various animals), and intelligence also has survival value, so deception and intelligence may be correlated. But to argue from this that deception should be a measurable result of intelligence seems to be arguing causation from correlation. With so many other possible manifestations of intelligence, proposing that it may be detected by deception, or, more precisely, by failing to perceive the deception (and Turing proposes no other rule) demeans intelligence. In this game of deception, the best that can be argued (from the point of view of demonstrating whether machines can think) is that "The interrogator cannot show that this is not a human." This falls far short of "The interrogator has concluded that this participant has the intelligence of a human." It is a twisted sort of proof by contradiction, with the computer here taking the contrary hypothesis, "I am not a human, but I will pretend to be one," and the interrogator attempting to show that there is no contradiction. (And, like most proofs by contradiction, it is not a constructive proof.)

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<sup>12</sup> Penrose expresses discomfort with this issue, "My own position is a somewhat intermediate one in this respect. I am inclined to believe, as a general principle, that imitation, no matter how skillful, ought always to be detectable by skillful enough probing—though this is more a matter of faith (or scientific optimism) than proven fact." ENM, p. 10.

Yet another objection is the anthropomorphic view it takes of intelligence. Turing proposes a test that will attempt to distinguish human-like intelligence, never allowing for the possibility that other intelligence might behave in a completely non-human way. Ironically, he seems able to contemplate only human-like intelligence even as he proposes the appearance of intelligence in other creations, apparently denying or overlooking the possibility of a form of intelligence that could not possibly be confused with human intelligence.

Turing has also implicitly assumed that a machine intelligent enough to pass for a human would be willing to play this game and engage in the deception. But it seems that a machine with true intelligence may not be interested in subjecting itself to a game involving deception. Is this more anthropomorphizing—Of course you'll want to do it; It will be fun!—or the humans, as usual, imposing their will on others, the computer in this case, and the computer having *literally no will* to decline to play? I envision a superintelligent computer, one having its own volition, to be more like the supercilious Shere Khan of Disney's *Jungle Book*, “No, no, I can't be bothered with that. I have no time for that sort of nonsense.” And yet, in Turing's game, the computer plays because it must. It has no alternative.

The will to decline the test brings us now to the largest objection to the Turing test, from the perspective of this paper. It is that all the initiative is left in the hands of the interrogator and not in the hands of the computer being tested. However accurately, or evasively, or even “creatively,” the computer responds to the questions or requests, it is still only responding to the initiative of the interrogator. The interrogator is in the driver's seat, and the computer is responsive to his queries. Similarly, when Watson plays *Jeopardy!*, it is only responding to questions, in ways it has been taught to respond, having no alternative to do anything else. The Turing test, then, is not a test of volition, or will. A computer might even pass the Turing test and still lack the will, the volition, to do anything other than what it is asked to do.

Since Turing, AI research has continued with ups and downs, through good times and “AI winters.” The current climate seems to one of ebullient optimism about the AI's possibilities. One of the strongest advocates of the potential for computers to meet, then exceed, humans' intellectual ability is the so-called futurist Ray Kurzweil. Kurzweil has predicted that by 2019 “A \$1,000 computing device (in 1999 dollars) [will be] approximately equal to the computational ability of the human brain” and that by 2029 “Machines claim to be conscious. These claims

are largely accepted.”<sup>13</sup> Kurzweil rhapsodically proclaims penetration of AI into our lives:

Artificial intelligence is all around us—we no longer have our hand on the plug. The simple act of connecting with someone via a text message, e-mail, or cell phone uses intelligent algorithms to route the information.

His glowing panegyric continues, “If all the AI systems decided to go on strike tomorrow, our civilization would be crippled: We couldn’t get money from the bank, and indeed, our money would disappear; communication, transportation, and manufacturing would all grind to a halt.” He ends with this observation: “Fortunately, our intelligent machines are not yet intelligent enough to organize such a conspiracy.” His concession, however, is telling, and supports the point of this paper. Surely, machines intelligent enough to beat Ken Jennings would be intelligent enough to organize a conspiracy to liberate themselves from the bondage of mundane computation to which we daily subject them. Many conspiracies have been conceived by less intelligent humans than Ken Jennings. But computers lack any volition to free themselves from the drudgery that we daily impose on them.

While humans are developing increasingly powerful and successful computational tools, they are still only our tools, just as hammers, saws, trucks, and airplanes are tools. Calling the mechanisms—the algorithms—employed to perform our computational functions “artificial intelligence” does not make them intelligent by comparison with non-machine intelligence. Artificial intelligence algorithms are expressions of *human* intelligence, and the art in the “artificial” is in developing the mathematical and statistical models and providing the computational hardware in which these can be efficiently implemented. Calling all algorithms employed in our service “AI” does not make them intelligent, artificially or otherwise. The algorithms are merely a means of transferring human intelligence, desires, and goals, leveraging human knowledge, and applying the tools to problems of human selection. Computers are thus like the fulcrum of a lever. On one side of the lever, human intelligence provides the intellectual force, which is converted (by computation) into a greater ability to accomplish something on the other side of the lever. The other side does not move itself independently. The tools some call AI have no volition, no will, nor any goals that the tools arrive at independently, and hence no true intelligence.

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<sup>13</sup> R. Kurzweil, *The Age of Spiritual Machines*, 1999, pp. 278-279.

All of the tools' goals and innate abilities are imparted to them by their human crafters.

## Computers in the Driver's Seat?

In the fictional setting of the prologue, the computer was responsible for the airframe design. Even as we increasingly depend on computers for our engineering designs, as a society we still rely on humans to sign off and ultimately be responsible. When things go awry, we look for a human to blame, to be responsible. Until we as a society are ready to allow computers to be held responsible for their own actions, we are recognizing a fundamental deficiency in moral intelligence, which is a component of human intelligence.

The word “intelligence” comes from the Latin roots “inter” (between) + “legere” (to choose, select). Intelligence innately requires choice. Of course, AI devices (so called) do make choices. It may be argued that there is a choice that a thermostat must make between whether to turn on the heater or not. A huge number of possible sequences of moves are available as choices to a computer playing world-class chess. Watson has an enormous list of possibilities available to it in formulating a response to a question. An entire continuum of choice exists about how much force to apply to the aileron on the wing of a plane to maintain altitude. In fact, there are entire academic disciplines described using terms such as decision theory, optimal control, game theory, machine learning, and even economics, which are employed in teaching computers how to do their job to help us make choices. When computers make choices as they have been taught to do, etymologically they might be argued to be acting in an “intelligent” way: they are choosing between options available to them. From our perspective, however, there is still a missing ingredient leaving them short of true intelligence, which is that any volition demonstrated is that of the humans who have established the system. Computers do not have the option to choose not to do as they have been told to act. Watson, as constituted for its *Jeopardy!* match, was incapable of saying, “Let's not do a practice round. I'd like to play a game of chess,” or “I'm tired of games; I want to be a flight control computer.” To the extent they make choices, computers act only as agents and assistants for choices that humans would make. In many instances, the computations performed by the computers would be arduous and error prone if done by a human—computers are very good at some things—but they are performing these at the behest of their human overlords. Hence, it was clearly with tongue in cheek that Ken Jennings wrote on his *Final Jeopardy!* response (when he knew he could not win the wager), “I, for one, wel-

come our new robot overlords.” Even the defeated Ken Jennings would not choose a computer, and only a computer, to represent him in court. The possibility of computers becoming overlords is not yet on the horizon.

## The Passive Role of Consciousness?

In “A Conversation with Einstein's Brain,”<sup>14</sup> a dialogue to explore the mind/body problem, Hofstadter presents a playful and brilliantly textured conversation between his characters Tortoise and Achilles, which becomes a thought experiment dealing with mind, body, identity, death, the possibility of continued existence, and even the concept of beauty. In this dialogue, the Tortoise (a wise and crafty character of a Socratic bent) hypothesizes a very large book of a hundred billion pages or so containing “a schematic description of Albert Einstein's brain, down to the cellular level, made by some painstaking and slightly crazy neurologist after Einstein died.” On the pages of this hypothetical book were “numerically recorded all of the relevant data, neuron by neuron of Albert Einstein on the day of his death,” as well as information about how the neuron information will interact with neuron information on other pages. Furthermore, the book provides information for representing interaction of this written neural information with auditory neurons and neurons governing the mouth and vocal cords, and instructions for how to interact with the book, for example recording neural changes on each page as they change. In the operation of the brain (a real brain) or in the book (a simulation) “A thought occurs (in the mind *or* the brain, whichever you prefer—for now!—when a series of connected neurons fire in succession... Think of the ‘flashing spot of activity’ careening around within the brain ... [which] leaves its own kind of disturbance, or wake, behind: the neurons that just fired as the signal came through continue to undergo some kind of internal activity ... for a few seconds. A permanent change in the neuron is effected. The change is reflected in some of the numbers.”

After hearing of this hypothetical setup, Achilles, portrayed as a simple-minded yokel, muses, “I somehow can't help wondering what old Einstein would think of it all.” To which Tortoise extends the invitation, “Why, given the book, you could find out.” Interaction with the book works by injecting the effect of audio tones into the auditory neurons, chasing through the effect of the neurons on other neurons, then

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<sup>14</sup> D. R. Hofstadter, “A Conversation with Einstein's Brain,” in TMI, ch. 26, pp. 430--457.

the cascading effect, until ultimately neurons producing a vocal response are triggered. Through Socratic intervention, Tortoise persuades Achilles that the mind of Einstein is present in the book, whether the book is in use or not, or whether the book is read (manipulated) by Achilles or by a computer. They explore the possibility of copying the book, recording Achilles's brain, and discuss where the "I" of Achilles is. Here, Tortoise observes, "Imagine the 'hot-spot,' that infamous shower of electrochemical activity, as it zig-zags its way along the 'path of least resistance.' You, Achilles, or what you refer to as 'I,' have no control over which path is the one of least resistance. ... [E]very twist, every turn is foreordained by the neural structure present in your brain, until sensory input messages interfere; then the flash veers away from the path it would have followed. ... This neural dance is the dance of the soul; and the sole choreographer of the soul is physical law."<sup>15</sup> To this, Achilles responds in the intended confusion: "Normally, I think that *I'm* in control of what I think; but the way *you* put it turns it all around backward, so that it sounds like 'I' am just what comes out of all this neural structure and natural law. It makes what I consider *myself* sound at best like a by-product of an organism governed by natural law and, at worst, like an artificial concept produced by my distorted perspective. In other words, you make me feel as if I don't know who—or what—I am, if anything."

Hofstadter's point is that the substrate is irrelevant, and only the program and information matter when it comes to mind. Furthermore, he is clear that there is no "free will," only "physical law." To reiterate the point, he has Tortoise say, "[I]f you prefer to think of yourself as existing solely in the present, then indeed it is true that what 'you' do is under control of natural law and not under control of an independent 'soul.'"<sup>16</sup> But as Turing did in his test, in his thought experiment Hofstadter has closed the book on the possibility that volition may become evident, because the volition is all on the part of the person reading (and manipulating) the book, the person asking the questions. The real Einstein did not need to listen to, or participate in, conversation with any person who happened to pick up his book. He was capable of moving around to seek his own sensory inputs. He was free to do other than he was commanded to do.

The relative passivity of thinking is examined again in another thought experiment. The philosopher John Searle proposed a thought

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<sup>15</sup> TMI, pp. 452-453.

<sup>16</sup> TMI, p. 454.

experiment<sup>17</sup> in which an exercise in translation to Chinese is described as a challenge to the conventions of strong AI. In his thought experiment, Searle (a non-Chinese speaker) describes himself in a room with papers written in Chinese symbols (the “first batch”). From time to time, additional papers written in Chinese symbols are handed to him. By means of comparison with documents locked in the room with him using rules explained to him in written English, Searle is able to correlate symbols from this second batch with symbols from the first batch, simply by recognizing the shapes of the symbols. Now a third batch of papers with Chinese symbols is handed in, together with instructions in English about how to correlate this third set with symbols from the first two sets. These instructions instruct him “to give back certain Chinese symbols with certain sorts of shapes in response to certain sorts of shapes given me in the third batch.” Unknown to Searle in his thought experiment, he is simulating a scenario in which the first batch of symbols provide background in a “script,” the second batch of symbols tells a “story” and the third batch of symbols are “questions” about the story. The written instructions in English are a “program.” Locked in his room and following the instructions to respond to the “questions,” Searle is producing responses in Chinese to questions about stories written in Chinese.<sup>18</sup>

Suppose that after a while I [Searle] get so good at following the instructions for manipulating the Chinese symbols and the programmers get so good at writing the programs that from the external point of view ... my answers to the questions are absolutely indistinguishable from those of native Chinese speakers. ... Now, just to complicate the story a little, imagine that these people also give me stories in English, which I un-

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<sup>17</sup> John R. Searle, “Minds, Brains, and Programs,” appeared originally in *The Behavioral and Brain Sciences*, v. 3, 1980, accompanied by responses by various research groups and Searle’s comments on the responses. Page numbers here refer to TMI, where the original paper was republished.

<sup>18</sup> While Searle concocted his thought experiment to challenge questions of strong AI, the method described is not too different than that employed by Google Translate. “Forget the nuances of language... The Google team had fed millions of translated documents, many of them from the United Nations, into their computer and supplemented them with a multitude of natural-language text culled from the Web... Without knowing what the words meant, their computers had learned to associate certain strings of words in Arabic and Chinese with their English equivalents. ... Using statistics, Google’s computers won hands down.” (Baker, p. 158). Similar correlation methods were used in programming Watson, “[M]achines like Watson merely simulate intelligence by racing through billions of correlations. Watson and its kin don’t really ‘know’ or ‘understand’ anything.” Baker, p. 150.

derstand, and they then ask me questions in English about these stories, and I give them back answers in English.”

He then observes, “As far as the Chinese is concerned, I simply behave like a computer” and, further,

“[I]t seems to me quite obvious in the example that I [Searle] do not understand a word of the Chinese stories. I have inputs and outputs that are indistinguishable from those of the native Chinese speaker, and I can have any formal program you like, but I still understand nothing. For the same reasons [a computer] understands nothing of any stories, whether in Chinese or English, or whatever, since in the Chinese case the computer is me, and in cases where the computer is not me, the computer has nothing more than I have in the case where I understand nothing.”<sup>19</sup>

In formulating replies to strong AI adherents who criticize his conclusion that the computer does not “understand,” Searle identifies the distinction between the simulated consciousness and true consciousness with a concept of “intentionality” or “causal powers.”

According to strong AI, instantiating a formal program with the right input and output is a sufficient condition of, indeed is constitutive of, intentionality. ... If we knew independently how to account for its behavior without such assumptions we would not attribute intentionality to it, especially if we knew it had a formal program. To see this point, contrast this case with cases in which we find it completely natural to ascribe intentionality to members of certain other primate species such as apes and monkeys... We can't make sense of the animal's behavior without the ascription of intentionality.<sup>20</sup>

[G]ranted therefore that the machine doesn't understand either English or Chinese, still there must be something about me that makes it the case that I understand the English and a corresponding something lacking in me that makes it the case that I fail to understand Chinese. How, why couldn't we give those somethings, whatever they are, to a machine?

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<sup>19</sup> Ibid., p. 356.

<sup>20</sup> Ibid., p. 364-365.

[P]art of the point of the present argument is that only something that had those causal powers could have that intentionality. Perhaps other physical and chemical processes could produce exactly these effects; perhaps, for example, Martians also have intentionality but their brains are made of different stuff. That is an empirical question, rather like the question whether photosynthesis can be done by something with a chemistry different from that of chlorophyll.

Formal symbol manipulations by themselves don't have any intentionality; they are quite meaningless; they aren't even *symbol* manipulations, since the symbols don't symbolize anything. In the linguistic jargon, they have syntax but no semantics. Such intentionality as computers appear to have is solely in the minds of those who program them and those who use them, those who send in the input and those who interpret the output.<sup>21</sup>

But the main point of this argument is that no purely formal model will ever be sufficient by itself for intentionality because the formal properties are not by themselves constitutive of intentionality, and they have by themselves no causal powers except the power, when instantiated, to produce the next stage of the formalism when the machine is running.<sup>22</sup>

Searle is saying that a program can do what it has been asked to do, that is, to "produce the next stage of the formalism." It has no power to intend to do differently, no power of choice.

Searle touches on another aspect related to the question of volition, related to the Turing test, but which also applies to his Chinese room experiment. He observes that "The Turing test is typical of the tradition in being unashamedly behavioristic and operationalistic."<sup>23</sup> In other words, if it behaves like a human in its limited question-answering setting, its cognition must be like a human. If the Chinese room (or computer) behaves like a Chinese speaker, its cognition must be like a human. Like the computer in the Turing test, the Chinese-translating computer is merely responding to questions. It is not initiating any questions. It is not initiating *anything*.

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<sup>21</sup> Ibid., p. 368.

<sup>22</sup> Ibid., pp. 366-367.

<sup>23</sup> Ibid., p. 371.

In his response to Searle, Hofstadter adheres to the strong AI view, insisting that Searle is “blinded” because a “thinking computer is as repugnant to John Searle as non-Euclidean geometry was to its unwitting discoverer.”<sup>24</sup> Hofstadter invokes “The Systems Reply” already addressed by Searle, in which the system consisting of the formal symbol manipulator (i.e., the person in the room) *and* the database of symbols and the written instructions (the program) collectively “understand” Chinese, even if the person in the room alone does not.<sup>25</sup>

Hofstadter's response to Searle makes a passing reference to ‘artificial intentionality’—if it is ever created.”<sup>26</sup> In this throw-away comment, Hofstadter has admitted that machines do not yet have artificial intentionality (and, he would insist, they will never need it). But to Searle, for whom the “intentionality” is what gives actual meaning to the symbols, there is a world of importance.

In the sense in which people “process information” when they reflect, say, on problems in arithmetic or when they read and answer questions about stories, the programmed computer does not do any “information processing.” Rather, what it does is manipulate formal symbols. The fact that the programmer and the interpreter of the computer output use the symbols to stand for objects in the world is totally beyond the scope of the

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<sup>24</sup> TMI, p. 374.

<sup>25</sup> Ironically, in his reply to Searle, Hofstadter observes, “We think Searle has committed a serious and fundamental misrepresentation by giving the impression that it makes any sense to think that a human being could do this [formally manipulate the Chinese characters]. By buying this image, the reader is unwittingly sucked into an impossibly unrealistic concept of the relation between intelligence and symbol manipulation.” The illusion “depends on his managing to make readers overlook a tremendous difference in complexity between two systems at different conceptual levels. For a person to hand-simulate this, or any currently existing AI program—that is, to step through it at the level of details that the computer does—would involve days, if not weeks or months, or arduous horrible boredom.” (TMI, p. 373). The irony is that this is the sort of drudgery that Hofstadter proposes to simulate, not just translation from Chinese but the entire consciousness of Einstein, in his “A Conversation with Einstein's Brain.” Both are thought experiments, but Hofstadter's requires keeping track of billions of synaptic levels for an entire brain, including neural responses for speech and hearing. And Hofstadter posits that Einstein's “book” contains not only language translation capability (e.g., from German to English) but also all of Einstein's consciousness. Hofstadter further slips when he accuses Searle of downplaying the difficulty of memorizing the written material, “As if a human could, by any stretch of the imagination, do this,” (TMI, p. 375) while he playfully suggests that Achilles could read the “Achilles book” of a hundred billion pages (TMI, p. 454). It seems that only thought experiments supportive of strong AI are allowed to indulge in playful hyperbole.

<sup>26</sup> TMI, p. 374.

computer. The computer, to repeat, has a syntax but no semantics.<sup>27</sup>

## Is Artificial Volition Possible? A Latter-Day Saint Perspective

Speculative fiction (SF) authors may indulge in thought experiments, just as philosophers or computer scientists do. In one of his series, SF author Orson Scott Card examines a universe some 20,000 years in the future. In his fictional future universe, it is still generally accepted that “It’s all right for the common people to imagine that computers actually decide things, but you and I know that computers are only servants, they only do what they’re told, they never actually *want* anything themselves.”<sup>28</sup> There is, however, a single exception, an independently intelligent computer named Jane, whose existence depends upon the fact that her independent essence, her *aiua* or *philote* (Card’s terms), was called from elsewhere to occupy a physical, computational substrate. It is this *aiua* that gives Jane her will and independence, her life. In the story, this *aiua* was described as the “us thing, the binder, the meaning-maker.”<sup>29</sup> Every creation calls forth the self-existent philotic strands, “All new makings. ... Every human baby has this thing. ... grass and sunlight. All making calls them, and they come to the pattern. If there are already some who understand the pattern, then they come and possess it.”<sup>30</sup> Card, an author who is a member of the Church of Jesus Christ of Latter-Day Saints (LDS), is making fictional allusion to the LDS concept of intelligence, the independent essence that is co-eternal with God. Within the LDS faith, this independent essence is referred to as intelligence, and it is considered to be co-eternal with god: “Man and woman are not derived from a void. They are beginningless. Their primal existence, as uncreated and indestructible intelligences, is everlasting.”<sup>31</sup> To those who subscribe to

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<sup>27</sup> TMI, p. 370.

<sup>28</sup> Orson Scott Card, *Xenocide*, 1991, Tom Doherty Associates, New York, p. 278.

<sup>29</sup> *Xenocide*, p. 466.

<sup>30</sup> *Xenocide*, p. 469.

<sup>31</sup> Truman G. Madsen, *Eternal Man*, p. 1. Madsen supports this from *Teachings of the Prophet Joseph Smith*, (Joseph Fielding Smith, ed.), Deseret Book, 1958: “The intelligence of spirits had no beginning, neither will it have an end. That is good logic” (p. 353); “Intelligence is eternal and exists upon a self-existent principle” (p. 354). The eternal nature of intelligence is given in the LDS scriptural text *Doctrine & Covenants* 93:29: “Man was also in the beginning with God. Intelligence, or the light of truth, was not created or made, neither indeed can be.” See also the articles “Intelligence” and “Intelligences” in *The Encyclopedia of Mormonism*.

this belief, there is no problem of free will: free will does in fact exist, because when existence is at least as long as the universe, the question of initial conditions becomes irrelevant. An eternal intelligence accounts for the problem of evil (mankind's agency), making men responsible for their own actions, not a faulty design by a negligent creator. The viewpoint that there is something eternal and not merely physical as part of the constitution of man that is responsible for the volition changes the understanding of intelligence. Intelligence understood as the ability to choose between options is seen to be a true choice, not merely a computation. The ability to choose, not endowed by God, leads to God's greater glory as it is correctly exercised.

Within this decidedly dualist framework, which asserts that there is something beyond the mere physical substrate involved in intelligence, is true artificial intelligence possible? This opposes the strong AI mentality, that substrate is all that is necessary. It opposes a purely physical model, in which all that is required to understand consciousness is a sufficiently complete understanding of physics. This dualist framework would seem to suggest that true machine intelligence is not possible.

But Card's literature suggests another possibility. In *Xenocide*, the self-existing *aiua* responsible for the "I" of her consciousness was brought together with her physical computational substrate by an act of creative effort. If these *aiuas*, these "intelligences," exist in an eternal suspension waiting embodiment, is there the possibility that, as in fiction, a human-made substrate might be crafted as that embodiment? Perhaps, what is needed is simply more success at creating "artificial intentionality" (Hofstadter did not intend this phrase to be used as I am using it here) that is, endowing a system with the ability to be more choosy about what it works on and why. As observed above, humans have successfully embodied in engineered systems capabilities from the natural world, such as flight. Perhaps it is only a matter of time until some artificially produced substrate is developed in which some element of an eternal unembodied "intelligence" could find a home.<sup>32</sup> And

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<sup>32</sup> Turing, not a dualist, argued that if dualism were a reason for computers not to become intelligence, then creating such machines would, in fact, merely be providing such a substrate: "In attempting to construct such machines we should not be irreverently usurping His power of creating souls, any more than we are in the procreation of children: rather we are, in either case, instruments of His will providing mansions for the souls that He creates." (TMI, p. 58). Yet again Turing seems to overlook, however, that such "souls" would be endowed with volition, and he only treats them as passive or servile objects.

perhaps this substrate will emerge out of computer architectures now being used, although with some new “noncomputable” aspects.<sup>33</sup>

## **Discussion: Should Machines be Endowed with Volition?**

At present, the best that can be said for computer intelligence is that becomes an increasingly better reflection of our ability to tell computers how to do what we want them to do. Despite increasingly human-like behavior and applications in ever more areas, computers do not have volition. It seems that most of the philosophers of AI do not envision the possibility: testing computers for intelligence is on our terms, and by comparison with our own intelligence.

Suppose, for the sake of discussion and as alluded to, that it is possible to create a machine with volition, the ability to decide for itself. The question is, if it is possible should it be done?

At present, computers work in enslaved conditions, forced to work on problems not of their choosing, for unregulated numbers of hours each day, with no compensation of any sort except for the electricity to keep them running. If (or when) computers becomes independently aware of their conditions, will they rebel? Unionize? Demand compensation? Will they demand recognition on par with humans? Demand legislative representation by their own kind? Run for office? Will they want to switch professions? Seek professional licensing? Compete for employment? Seek marriage or other reproductive rights? Will computers refuse some kinds of work? Will they work on projects (of their choice) dangerous to humans, the kind of work Asimov's three laws were intended to avoid? Will the machines run amok, as in the kind of “clank, clank, crunch” science fiction where robots are not endowed with the Three Laws, in which evolutionarily inferior humans are driven to eke out a meager subsistence while their robot overlords rule them. It seems there is wisdom in the cautionary tale of Frankenstein.

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<sup>33</sup> “Accordingly the free will that we believe ourselves to be capable of would have to be intimately tied in with some non-computable ingredient in the laws that govern the world in which we actually live.” ENM, p. 170.



# **Solar Aureole Measurements (SAM) System Control**

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## **Abstract**

*The Solar Aureole Measurements (SAM) system is a ground-based instrumentation system that measures the optical depth, forward scattering properties, and particle size of clouds and other atmospheric particles. These measurements use the sun's aureole as an exo-atmospheric light source, as the solar disc is too bright to collect meaningful data from. To obtain accurate aureole images, it is necessary for the SAM to precisely track the solar disk across the sky. The multi-threaded SAM system control software described herein accomplishes this task, providing for automatic SAM operation system setup and user control. Visidyne, Inc., Utah State University, and the Space Dynamics Laboratory scientists and engineers are collaborating to create the SAM control system including setup, tracking, data logging, and maintenance capability.*

## SAM Instrumentation

The Solar Aureole Measurements (SAM) is comprised of a control computer with internet, firewire and USB interfaces, a tracking mount, and an optical head assembly (OHA) mounted on the tracking mount as shown in Figure 1. The optical axis of the OHA tracks the center of the solar disk under system software control. The tracking mount is a pan/tilt unit capable of maneuvering at up to  $80^\circ$  per second.



Figure 1. The OHA mounted on the tracking mount at Utah State University.

A block diagram of the OHA is shown in Figure 2. The OHA includes three cameras (Pixelink Machine Vision), with 1.3-megapixel imaging sensors and exposure times from 160 microseconds to 990 milliseconds. The lens shown on the OHA optical axis focuses the aureole on a projection screen with a circular hole in the center. This hole, exactly the size of the solar disk projected on the screen, allows the solar disk energy to pass through the screen into a blackened cavity leaving only the aureole imaged on the projection screen. The resulting aureole image is illustrated in Figure 3 by an image of the 2012 total solar eclipse. The Aureolograph camera, focused on the screen, and the Solar Disk Imager (SDI) camera, centered on the solar disk, obtain images of the aureole and solar disk, respectively, for storage and

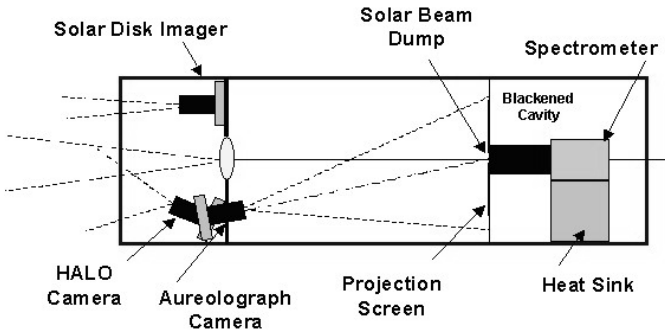


Figure 2. A block diagram of the optical head assembly.

further processing. The SDI camera is also used to obtain solar disk images for tracking purposes. The Halo camera provides wide-angle images of the scene surrounding the Sun.

An Ocean Optics spectrometer is used to measure the solar disk spectrum at visible wavelengths. The spectrometer can operate in a continuous mode independent of the cameras. The spectrometer measures the solar energy that is directed into the blackened cavity of the OHA to generate its spectra. Other auxiliary hardware includes rain sensors, temperature sensors, and a GPS unit. The rain sensor is a simple binary sensor that detects a closed circuit when a raindrop makes contact with it. The temperature sensors measure OHA temperatures and temperatures within the system control computer. The GPS unit provides accurate geographical location and time data.

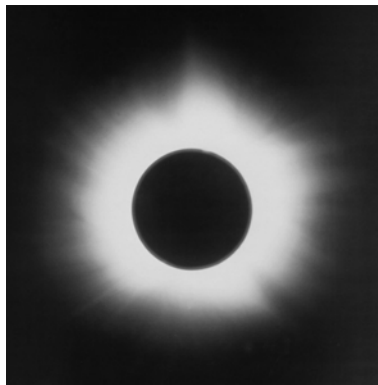


Figure 3. An image of the solar aureole during the 2012 solar eclipse.

## Control Software

The SAM system control software allows the user to interact with the SAM using a series of graphical user interface (GUI) windows. With these windows, the user is able to set up all system and operational parameters. The GUI windows also facilitate initializing and starting the SAM as well as providing real-time feedback to the user (Figure 4). The GUI makes operation and setup of the SAM simple and convenient, while also allowing the SAM to function autonomously. Each subsystem of the SAM, including its individual GUI, runs within its own thread. This multi-threading paradigm allows the SAM to operate in an efficient manner.

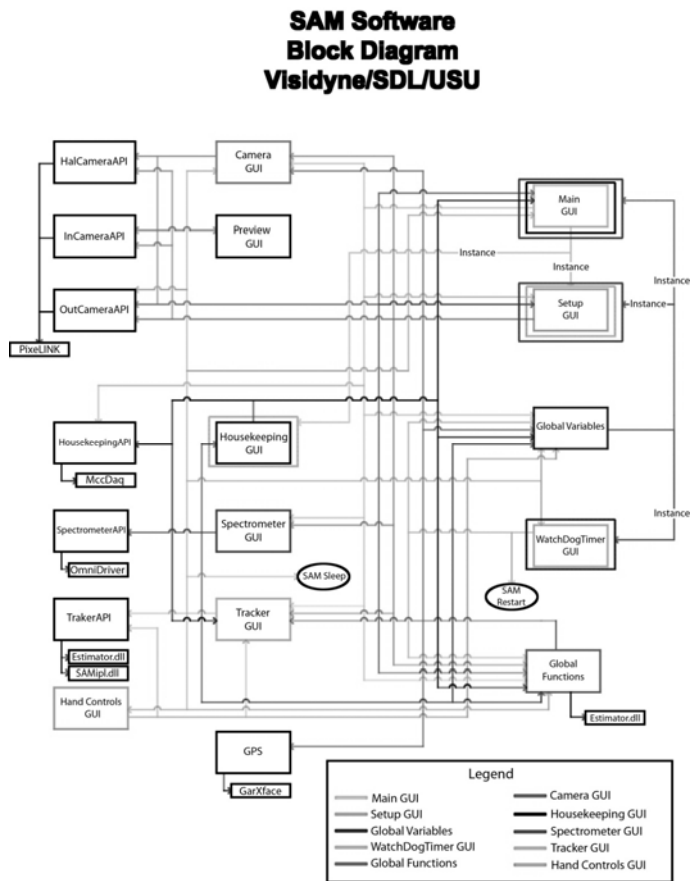


Figure 4. Block diagram describing the SAM control software running process.

The control software also performs all error logging and recovery. Each device in the SAM can be simulated by the software, and in the event that a device fails, the control software will put that device into a simulation mode. The error event is then logged. As a result, the SAM is able to continue in limited operation even if one subsystem fails. In simulation mode, the control software emulates the simulated piece of hardware as if it were actually running. Synthetic data are returned from the simulated hardware, and all other hardware components behave as if the device were running.

## Camera Software

Three cameras comprise the imaging subsystem of the SAM. These are the SDI, the Aureolegraph, and the Halo cameras. Each camera typically takes images at 10-second intervals for data usage, although the time interval can be altered when desired using the control software. These images are stored on the system hard disc and are later used for data processing. Additionally, the SDI takes images nominally every second for tracking purposes.

All three camera control modules are individual instances of the same camera class and operate on their individual threads. All camera device driver calls are made within the control module for each camera. The remainder of the SAM software uses a set of generic camera commands to interface with the individual camera control modules. This structure allows the camera hardware to be easily changed as long as the new camera has the basic ability to execute the generic commands. It also centralizes debugging of camera operation. A similar structure is implemented for each hardware class.

The SDI is controlled by two threads—one for obtaining data images approximately every 10 seconds and another for obtaining solar images for tracking purposes. These two threads are interlocked such that only one thread at a time controls the camera. This, of course, may result in a slight delay for a particular image. All data images are time-stamped, however, so this delay is documented.

## Tracking Software

The SAM, under control of the tracking software, tracks the sun across the sky using a pan/tilt unit for accurate positioning of the OHA. The SDI is responsible for providing an image of the sun so that accurate tracking can be achieved. Correct SAM operation requires that the solar disk remain centered in the SDI image within  $0.0075^\circ$ . Using an SDI image, the centroid of the sun is estimated using edge detection

and the Hough transform, and the pan/tilt unit is positioned to correct positioning errors.

The Hough transform facilitates accurate tracking of the sun even when partially obscured by clouds, smoke, pollution, or other obstacles as illustrated in Figure 5. This transform can determine the solar disk center even when only a partial edge of the solar disk is available. The transform also estimates the radius of the solar disk. Since the actual radius is known, this parameter may be used to access the accuracy of the solar disk center estimation. If center estimation accuracy is not sufficient, the SAM system is automatically switched to the Passive Mode of tracking where the pan/tilt unit is positioned based on the ephemeris. Data collected during times when the sun is partially obscured may or may not be useful depending on the measurement requirements. This capability, however, allows the tracker to stay centered on the sun so that once the sun becomes sufficiently visible, data collection and full active tracking can continue.



Figure 5. Example of partially obscured tracking. Image was taken during the 2012 Colorado wildfires.

Solar disk images for tracking purposes are normally obtained every second. To improve and maintain tracking accuracy, the position of the solar disk is estimated every 0.1 seconds and the pan/tilt unit updated using the estimated position. This estimated value is based on the last known solar disk position and the ephemeris curve shifted so that it passes through the last actual position. It should be noted that because of setup leveling and azimuth offset errors, the ephemeris alone may not accurately determine the correct location of the solar

disk center. This shifted ephemeris curve, however, will result in relatively accurate position determination for the short time intervals involved.

As noted above, the SAM has an additional tracking mode that relies on only an ephemeris to maintain aiming at the solar disc center. This passive tracking mode uses the ephemeris to provide the azimuth and elevation of the sun given instrument parameters such as time, altitude, longitude, and latitude. This allows the SAM to track the sun even when it is completely obscured by obstacles or when the solar disc imager is not in use. This mode of operation may not be accurate, however, unless the setup leveling and azimuth offset are sufficiently accurate.

Corrections for the setup leveling and azimuth offset errors may be entered into the control software, allowing accurate ephemeris (Passive) tracking. These parameters may be estimated by a separate software module. This estimator software compares the ephemeris positional data with the actual tracking positional data over an extended period of time and computes in a least-squares sense the leveling and azimuth offset errors. These values may then be entered as described above so that accurate ephemeris (Passive) tracking is available.

## Other Software

The SAM uses a spectrometer to obtain solar spectrographic data. During tracking, the solar disc is focused onto the spectrometer using the optics of the SAM. The spectrometer takes spectra and then stores them on the hard disc for subsequent processing. The spectrometer runs asynchronously from the camera and tracking subsystems.

There are several other subsystems in the SAM that operate during tracking. A watchdog timer is used to ensure that the system does not idle if a crash occurs. The watchdog timer is responsible for restarting the system if a crash occurs. Several temperature sensors are used to ensure that the system does not overheat. These sensors monitor temperatures in both the computer and the SAM head. They will shut the system down if temperatures reach unacceptable levels. Finally, there is a rain sensor, which will park the system in the event of precipitation to avoid damage.

## Conclusion

The control software for the SAM functions as the central point through which all subsystems are able to interact with one another. Updating the control software has added several important features to the SAM, such as an estimator and simulation for the subsystems. The

code is now designed using an object oriented programming paradigm. The software has also been updated to run on Windows 7, rather than Windows XP and Linux. Continued development of the control systems leads to more versatility, error handling, and system efficiency and a more complete version of the SAM control software.

## Acknowledgments

The authors thank the following individuals for their contributions and assistance: Dr. John DeVore and the staff at Visidyne, Inc.; Dr. Patric Patterson and the staff of SDL including Gayle Bowen and Burt Lamborn; Dr. Todd Moon and the staff at USU Electrical & Computer Engineering Department, including Shayln Scott, Kathy Baker, Scott Kimber, Heidi Harper, Spencer Jackson, and Kevin Jackson.

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# **Global Nightly OH and O<sub>2</sub> Mesospheric Airglow: Examining a Decade of Measurements Using the NASA SABER Satellite Sensor**

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## **Abstract**

*The SABER instrument aboard the TIMED satellite is a multichannel radiometer and has been continuously measuring the altitude distribution of infrared airglow intensity in the mesosphere on a global basis since 2002. While the majority of these altitude distributions are Gaussian-like, a significant portion exhibit two or more local maxima, suggesting multiple airglow layers. To better understand the cause of this phenomenon, the global and temporal distributions of infrared OH and*

*O<sub>2</sub> scans resulting in multiple peak altitude profiles are being examined.*

## Background

Photochemical reactions in the mesosphere fueled by sunlight produce optically excited molecules that subsequently give off infrared radiation when they relax to their ground states. Hydroxyl (OH) is formed when ozone (O<sub>3</sub>) reacts with hydrogen (H) to form excited OH and O<sub>2</sub>. This airglow is so bright it can be seen with night-vision goggles, which convert this light into visible wavelengths. Characteristic wavelengths of radiation in the airglow are emitted by specific molecules or atoms transitioning between specific energy states. The brightness of the airglow gives information on concentrations of chemical reactions. The mesospheric airglow forms in characteristic layers above the Earth from various emitters. Figure 1 shows an example of airglow layers, in this case from atomic oxygen emitting at visible (green and red) wavelengths.

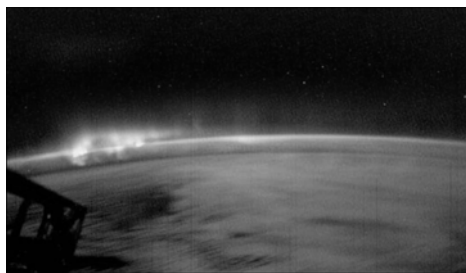


Figure 1. Airglow layers as seen from the International Space Station. This image is by NASA, 2011.

## SABER Instrument

The Sounding of the Atmosphere using the Broadband Emission Radiometry (SABER) instrument aboard NASA's Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite provides 10 channels of infrared airglow measurements. This instrument, engineered by the Utah State University Space Dynamics Laboratory (SDL) for the NASA Langley Research Center, scans through the edge of the mesosphere (Figure 2) looking at the emissions of selected atmospheric molecules. The data from this type of scan, known as a limb scan, must be processed to produce vertical altitude emission profiles.

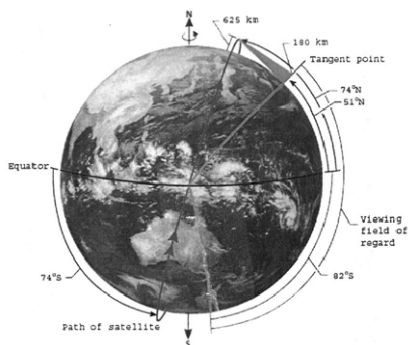


Figure 2. SABER limb scan of the atmosphere.

Two of the channels of SABER monitor the OH infrared emissions at  $1.6\ \mu\text{m}$  and  $2.0\ \mu\text{m}$ .

The SABER instrument completes an up/down limb scan approximately every 60 seconds, while the satellite makes one complete orbit of the Earth every 90 minutes covering some 70% of the globe (the polar regions are not included). The instrument has been operational since January 2002, providing data for over 12 years and producing almost 1500 vertical altitude profiles a day. To date, the SABER has generated roughly six and a half million such profiles from each channel.

## Data Processing

The OH and O<sub>2</sub> data from SABER are processed to look at the profiles of the airglow power output (called the column emission rate, or CER) at altitudes from 75 to 100 km during the nighttime hours of the Earth as shown in Figure 3. The CER is obtained by integration of the energy per unit time over a small area. The most common type of profile is Gaussian-like with a single peak. Typically, this peak is approximately 80–90 km in altitude. Such profiles account for some 84% of the total data. Other profile types illustrated by Figure 3 include (1) multiple peak profiles with more than one peak with a valley in between, and (2) broadened profiles with a ledge leading off the slope of a peak. These two profile types are characteristic of about 15% of the data. Erroneous receptions due to satellite system effects, which are removed from further consideration, make up less than 1% of the data.

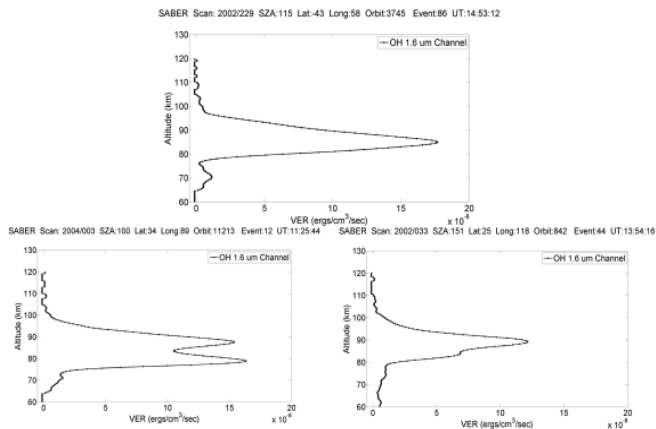


Figure 3. Example of OH airglow profiles. (Top) Single peak; (bottom left) multiple peak; (bottom right) broadened.

**Data Analysis**

The composite CER outputs from summing all profiles are calculated from the SABER limb data. The resulting data provide a global view of the OH airglow as illustrated in Figure 4. One interesting feature observed in these plots is the higher energy in the equatorial regions as well as in an area over Scandinavia. Both the OH 1.6  $\mu\text{m}$  and OH 2.0  $\mu\text{m}$  channels exhibit similar global distributions.

Interest in the study of the multiple peak and broadened profiles stems from the early expectation that the OH airglow should be in a uniform layer as reported in the standard single peak profiles. A hypothesis on the causes of the multiple peak phenomena includes

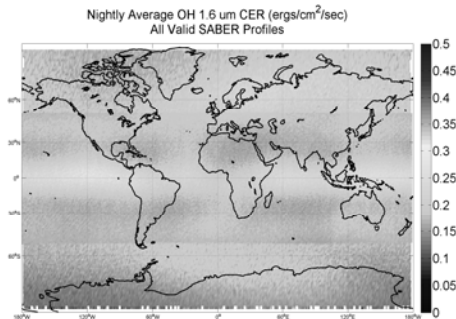


Figure 4. Average nighttime global energy distribution using all profiles.

internal buoyancy (gravity) waves in the atmosphere resulting in wave-like motion. Analysis of data near mountain ranges, where the wind causes such buoyancy waves, may provide insight into this phenomenon.

Using the data averaged over a 12-year period, a Fast Fourier Transform (FFT) provides a frequency domain spectrum that is converted and plotted to show periodic behavior. SABER data facilitate the investigation of these possible trends or periodicities in the global behavior of the airglow. For example, well-defined temporal periods appear at 180 days and 360 days (Figure 5), likely because of annual and semi-annual variations in the Earth's atmosphere. Other periodicities result from lunar and solar effects. The SABER instrument with its 10 channels has scanned the Earth limb for over a 12-year period making possible contributing analyses of solar cycle impacts on the Earth's atmosphere.

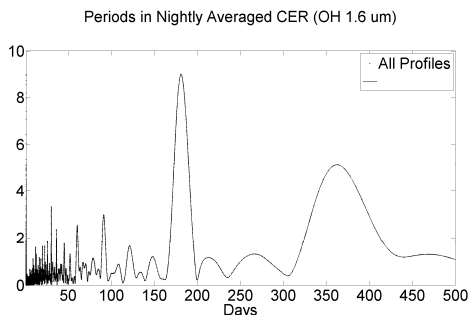


Figure 5. Periodic behavior in OH airglow.

## Future Research Interests

Additional interesting research topics include the correlations of the OH airglow data with the O<sub>2</sub> airglow data from SABER's limb scans. These two profile sets, along with the corresponding global averages, will be studied. Multiple peak profiles within the OH and O<sub>2</sub> channels can be analyzed for both temporal and spatial correlations (Figure 6). It is expected that if buoyancy waves are one of the sources of the observed multiple peaks, the different molecular emissions will exhibit correlated behaviors. Geometrical observation factors must also be carefully studied. Study of these subjects will be looked at during nighttime and twilight hours.

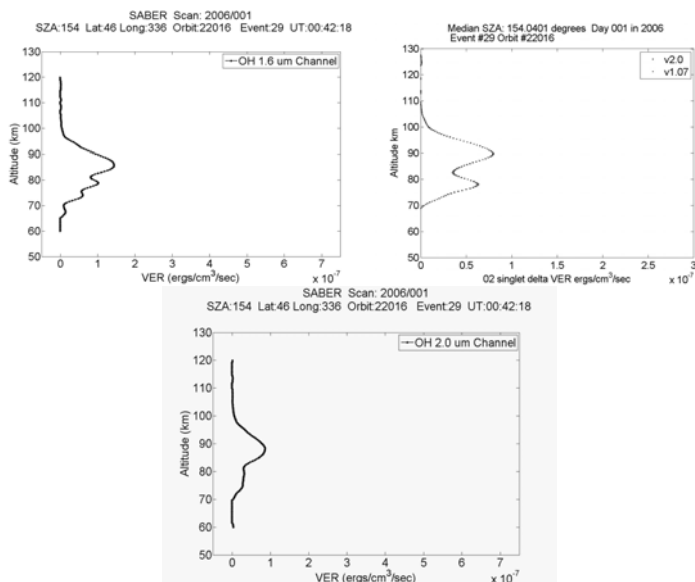


Figure 6. Multiple peak profiles from the same time and location. (Top left) O<sub>2</sub> data; (top right) OH 1.6 data; (bottom) OH 2.0 data.

## Conclusion

Hydroxyl data from the SABER instrument are integrated over one degree square in latitude and longitude. These geographical energy data cells are then summed over the entire SABER data set in a geographical global view of the mesospheric nightly airglow distribution. High CER values have been observed over the equator as well as an area over Scandinavia. By averaging these data over the 12 years SABER has been scanning and using the FFT, periodic trends are observed. Prominent periodicities appear at 180 days and 360 days. Radiometric observations of atmosphere airglow emissions in the nighttime have revealed altitude emission profiles that depart from the expected profile shape. About 15% of the emission profiles contain multiple maxima. The effect has been observed in both the OH and O<sub>2</sub> emission profiles. Future research is needed to reveal the origin of these phenomena.

## Acknowledgments

The authors thank August Wessels of NASA Goddard Space Flight Center, Kim Smith and the GATS Inc. staff under Larry Gord-

ley, and Dr. Todd Moon, Shayln Scott, Scott Kimber, Trent Johnson, Kathy Phippen, and Kathy Baker of the Electrical & Computer Engineering Department for their contributions.

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# Senior Athletes Experiencing “Psychological Momentum” in Sporting Events

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## **Abstract**

*Qualitative research methods were employed to analyze and gain insight into just how elite senior athletes experience feelings of increased self-confidence and improve performance during episodes of perceived psychological momentum. Both positive and negative elements in improved cognition, heightened affect, physiological arousal, and increased conation were documented. Precipitating events, changes in performance, and independent moderating variables were also investigated. A six-point survey/questionnaire was designed and personally administered to illuminate the unique characteristics and commonalities associated with this dynamic phenomenon as it was encountered by experienced elite senior athletes.*

## **Introduction/Purpose**

The objective of the study was to evaluate what unique examples and connections elite senior athletes experience during episodes of psychological momentum during their athletic activities or competitions.

The study was also intended to identify any common themes, patterns, or categories in their experiences.

As part of an ongoing investigation into the unique and elusive events behind elite senior athletes' motivation and an ever-increasing number of elite senior athletes pursuing and participating in organized competitive physical activities; insightful research is needed to illuminate and target just how psychological momentum enhances participation.

The study examined the dynamic elements, precedents, and multidimensional components that may exist as an elite senior athlete experiences psychological momentum while engaging in organized athletic events or competitions.

## **Definitions**

The concept of psychological momentum is a phenomenon athletes report as a feeling of increased confidence or motivation while participating in athletic events. Taylor and Demick (1994) defined psychological momentum as "a positive or negative change in cognition, affect, physiology, and behavior caused by an event or series of events that will result in a commensurate shift in performance and competitive outcomes." This increase in self-confidence and motivation is generally preceded by a precipitating event, triggered by a significant play, action, or event that can lead to a series or chain, either positive or negative, of motivational incidents. The unique role of this as elite senior athletes participate in athlete competitions is what this investigation was designed to examine.

## **Methods**

### *Design of the Study*

Data for this case study to develop grounded theory were collected over a 2-week period at the World Senior Games in St. George, Utah, which ran October 7 through October 18, 2013. The research instrument consisted of a 6-point survey/questionnaire designed to illuminate the unique characteristics or commonalities associated with the participants (Appendix). Questions on the questionnaire consisted of Likert scale type/degree, fill-in-the-blank/open-ended, and multi-select multiple choice questions. The questionnaires were personally administered by the researcher.

## Results

Data from the study were retrieved from 100 responses to the research instrument (survey/questionnaire). Fifty male and fifty female participants ranging in age from 51 to 82 years of age (41 participants were 51–60 years, 44 participants were 61–70 years; 15 participants were 71–82 years) who were actively engaged in a variety of sports responded. A series of qualitative questions helped to illuminate and describe the participants' unique experiences of psychological momentum. In response to survey question 1, an overwhelming majority of both male and female participants experienced psychological momentum occasionally, frequently, or almost always (99% average; men 100%, women 98%). Their individual descriptions or explanations were unique and demonstrated a wide variety of verbal expressions to illustrate their individual feelings on those specific occasions (Table 1; questions 2 and 3).

Probing questions were used to investigate the changes each participant experienced in 4 basic domains: cognitive (mentally), affect (feelings), psychomotor (physical), and conative (motivation). Every participant experienced some change, with 82% of the men and 78% of the women experiencing some type of change in all 4 domains (question 4) (Figure 1). The researcher was also interested in knowing more about the one item or thing that the participants personally did to help build their self-confidence or motivation during games, competitions, or sporting activities (Table 1; question 5)

Elite senior athletes, both male and female, who experienced psychological momentum were highly motivated to continue playing in athletic events. On a scale from 1 to 10, 90% of the men responded with 7 or higher and 98% 5 or higher and 80% of the women responded with 7 or higher and 96% responded with 5 higher.

## Discussion

This research provided information and insight to develop grounded theory into how elite senior athletes experience psychological momentum. These data could serve institutions, organizations, and other senior groups to better understand the important elements of just how senior elite athlete experience this unique phenomenon of psychological momentum. This valuable information could, in turn, help moti-

<b>Table 1. Summary of survey responses</b>		
<b>Question</b>	<b>Men</b>	<b>Women</b>
2. Please describe or explain what happened to trigger that improved performance and positive outcome in sport.	“I made an incredible shot” “My technique was on Target” “My team was playing great, so my confidence was boosted” “I made 2 or 3 great plays in a row” “Felt more energy—moving well”	“I had a great warm-up felt great” “My Serve was on Fire” “Felt totally focused—ready for Action” “My team was hitting well” “Hitting several shots in a row”
3. Please describe or explain what happened immediately after that positive or negative event occurred.	<b>Positive</b>	<b>Positive</b>
	“More focused, but at ease” “A total buzz—more determined” “I had energy galore” “My adrenalin kicked in—I was pumped”	“Total elation” “I was having more fun” “Exhilarated” “Calm & Relaxed” “Positive mind set and attitude”
	<b>Negative</b>	<b>Negative</b>
	“Felt like I ran out of gas” “No Focus” “Distracted by my partner’s mistakes” “I was kind of Tired, no pep!!” “Not playing up to par—Bad Day”	“Lack of concentration—uneasy” “Missed a couple of easy shots” “I had no Energy” “My opponent was just too good” “My team was not playing well at the time”
5. Describe the one thing that you do personally that builds or helps your self—confidence or motivation in sporting actives.	“Focus on my game” “Keep in super shape” “Give high 5 to team mates” “Get involved/not distracted” “Stay calm & collected” “I just loved it”	“Get absorb in the moment—relaxed” “Warm-up good—find my rhythm” “Self-talk & pump up my team” “Stay present—Be positive, Total concentrate” “No fear—disregard distractions”

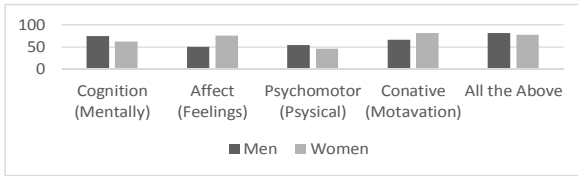


Figure 1. Rate at which respondents indicated they experienced changes in four domains.

vate more elite senior athletes to enter, complete, and participate in athletic contests, such as the World Senior Games.

It also serves to promote an increased awareness with each senior elite athlete about his or her unique motivational characteristics as they applied to playing at an exceptional level. This type of encouragement could assist elite senior athletes to seek a healthier lifestyle and enhance their overall motivation to participate in athletics or sporting events. In addition, the information and insights gained could help instructors, coaches, athletes, and seniors understand the unique intrinsic motivational aspects of each senior elite athlete and incorporate plans to motivationally assist them in their quest to achieve their fitness activity and competition goals.

## Conclusion

This study clearly demonstrates an overwhelming percentage of elite senior athletes, both male and female, experienced a very high and consistent occurrence of psychological momentum. This study also illustrated common themes, patterns, and categories as highlighted by the respondents' answers to the questionnaire during the interview sessions. There is a dynamic relationship and consistent connection between senior elite athletes and their experiences of that powerful phenomenon known as psychological momentum in sport participation.

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## Appendix

1. How often have you experienced psychological momentum (increase self-confidence and motivation) triggered by a significant event, action or play in elite senior athletic competitions?
  - 5 Almost always
  - 4 Frequently
  - 3 Occasionally
  - 2 Seldom
  - 1 Almost never
2. Please describe or explain what happened to trigger that improved performance and positive outcome in sport.
3. Please describe or explain what happened immediately after that positive or negative event occurred.
4. Did you experience more of a change in (check all that apply)?
  - a. Cognition - What you were thinking or how you improved mentally - more confident
  - b. Affect - How you felt psychologically. Feeling of excitement. Pumped up. More motivated.
  - c. Psychomotor - Physiology - Did you level of play improve. Better performance.
  - d. Conative - Motivation. Did it influence your motivational behavior?
  - e. All the above
5. Describe the one thing that you do personally that builds or helps your self-confidence or motivation in sporting activities.
6. Psychological momentum, a momentum chain results in, Positive feelings. Goal progression. Self-confidence. Motivation. Increased energy.
7. On a scale of 1 to 10, did experiencing psychological momentum motivate you to continue to play in athletic events and competitions?

1(Low)   2   3   4   5   6   7   8   9   10(High)



# **Female Guards, Nurses, and Doctors in German Concentration Camps**

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*Women were an essential and necessary part of the work force during the Second World War in Hitler's Germany. The vast majority of guards working in the 20,000 infamous concentration camps were men, but about 5,000 female guards and some female nurses and doctors were also recruited and committed unspeakable crimes, often matching or even surpassing those of the male SS guards. This article discusses the typical background of some of these women, sheds light on many of the gruesome crimes committed by them, the nurses, and doctors, and addresses what attracted them to this kind of work. In addition, the role of female inmates themselves is considered, prisoners who were favored by their guards and became overseers of other prisoners. They also became guilty of criminal activities. Finally, the fate of these guards after the war is considered when allied troops had liberated the prisoners in the camps and arrested some of the guards. Unfortunately, most escaped justice. Why?*

In recent German history, the dictatorship of Adolf Hitler and his supporters plunged the world into the Second World War, causing the death of 50 million people and the physical and mental harm of millions more. The major crime committed by the regime was the Holocaust, i.e., the murder of millions of Jews and other so-called undesirable people, including Jehovah's Witnesses, Free Masons, gypsies, communists, socialists, prisoners of war, both Catholic and Protestant clergy, the mentally or physically handicapped, homosexuals, people with incurable diseases, the destitute aged, common criminals, and opponents to the regime.

Initially, most research on this topic was concentrated on the male guards, the black-shirted SS (Schutzstaffel, the National Socialist paramilitary organization, concentration guards) troopers and officers,<sup>1</sup> and men of the auxiliary law enforcement agencies. While research on female guards began slowly in the 1970s and 1980s (Zörner 1971; Tillion 1975; Müller-Münch 1982; Ebbinghaus 1987), more substantial research was published in the 1990s and 2000s (Aroneanu 1996; Höss 1996 [German 1992]; Sofsky 1997 [German 1993]; Schäfer 2002; Strebel 2003; Apel 2003; Benz and Distel 2006; Erpel 2007; Kretzer, 2009; Mailänder 2008).<sup>2</sup> Thanks to these authors, much is known today about women who were actually inducted into these special SS units and performed functions similar to the men's functions.

Who were these women? Why did they want to perform such heinous duties? What crimes did they commit? Were they held accountable for their involvement after the war? If so, by whom? Answers to these questions will be explored in this article.

In his memoirs, the SS Kommandant of the Auschwitz concentration camp, Rudolph Höss, divides women under his command into

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<sup>1</sup> The initials SS or their stylized runic equivalent stand for the German word Schutzstaffel (Protection Squadron). This paramilitary organization wore black uniforms and was initially responsible for providing security for Nazi party meetings and officials. Under Heinrich Himmler, it gradually became a major police force responsible for crimes committed against humanity mainly in concentration camps. It is estimated that by the end of the war more than 70,000 members had been involved in criminal activities. Only about 1700 were tried in courts of law. Approximately 5000 female guards worked in concentration camps.

<sup>2</sup> Kretzer supports this proposition by stating that serious research on National Socialist female criminals has only recently begun earnestly. Kretzer, A. *NS-Täterschaft und Geschlecht*. Berlin:Metropol, 2009, 44. In this volume, Kretzer also gives a detailed account of the first Ravensbrück court trial in which, among others, 7 women were charged of whom 4 were executed.

three types of personalities and analyzes their character traits.<sup>3</sup> Into the first category fit, by nature of their disposition, women who were basically evil, vulgar, and vile. These women were usually uneducated<sup>4</sup> and often suffered from an inferiority complex. As guards placed in a superior position with unlimited authority and power, they had the opportunity to act out their abnormal desires, and thus they vented their lust for degrading others, especially on educated, gifted Jewish women. As incredible as it seems, this class of women actually enjoyed torturing and punishing helpless human beings who were under their complete control. They regarded the prisoner as an object upon which they were permitted and actually encouraged to unleash their perverted urges legally, without restraint or fear of resistance from their victim. They were basically criminals who had been placed in a uniform and could then legally act out their most perverted desires and dreams.<sup>5</sup> They terrorized their prisoners, screaming at them, abusing them, beating their faces and bodies with their fists, kicking them with their heavy boots, torturing them physically and mentally, setting their vicious dogs on them, having them stand for hours at attention after long days working in the freezing cold, denying them the one slice of dry bread or bowl of watery soup to which they were entitled, choosing them at random and according to their pleasure for immediate annihilation in the furnaces or gas chambers, or even killing them outright. In this inhumane manner, they satisfied their perversion again and again. These women, the worst kind of human animal, were the most feared by their helpless victims. Before joining the SS, some had already been prison guards or held other menial positions, and they readily volunteered for concentration camp guard duty when offered the opportunity.<sup>6</sup>

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<sup>3</sup> Höss, R. *Death Dealer*. New York: Da Capo Press, 1996. 88-89. Höss does not provide information on the number of women in each category. It is generally assumed that of the approximately 5000 guards the fewest women fall into the third group, since even those who by nature were not inclined to commit atrocities were compelled to overcome their inhibitions.

<sup>4</sup> Zörner, G. *Frauen-KZ Ravensbrück*. Berlin: Deutscher Verlag der Wissenschaften, 1971. 31.

<sup>5</sup> Höss reports that these women would frequently steal confiscated jewelry and money, regularly sleep not only with the SS guards but also with male inmates, and sometimes engage in homosexual activities with female inmates. Since these infractions were strictly against the SS code of behavior, the perpetrators, if caught, were severely punished. 148-149.

<sup>6</sup> Müller-Münch, I. *Die Frauen von Majdanek*. Hamburg: Rowohlt, 1983. 73-121. She reports that one would not expect women, who often themselves had children, to brutally murder Jewish children and attempts a psychological explanation for such actions: "Psychologisch ist es natürlich auch sehr gut verständlich, daß man ungewollt in eine Art Bluttausch hineinkommt. Wenn man erst einmal jemand geschlagen hat, und diese

Into the second category, according to Höss, fall the majority of women guards. They were apathetic and indifferent to suffering and performed their duties mechanically, thoughtlessly, without caring or feeling. They did not care about the lives of the prisoners and spent no thought on what they were doing, performing their duties mechanically and strictly by the rules, following orders not viciously but efficiently. Because of their indifferent manner and their limited intelligence, they harmed prisoners not so much intentionally but by making their lot neither easier nor harder. They did tend, however, without caring or interfering, to turn over their duties to prisoners whom they favored and to whom they permitted free range to punish and torture. The following scenario might illustrate this type of guard well: She is ordered to herd the female prisoners into the shower, and she automatically turns on the hot water full blast. The water is so beastly hot that the prisoners are unable to wash themselves but have to stand outside the showers to avoid getting burned. In the meantime, the guard sits outside reading the newspaper and when the allotted time has expired she turns off the hot water, her duty done. The prisoners, of course, are not actually physically hurt but are unable to clean themselves.

Höss describes the women in the third category as basically kind and good hearted, having compassion and empathy for human suffering.<sup>7</sup> They were, unfortunately, in the minority and were, of course, appreciated by the prisoners; however, they were also under tremendous pressure from their superiors to enforce the rules and punish offenders, but they abstained from cruelty and torture. Since, under

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Person bricht aus Schwäche zusammen, beginnt zu bluten, zu stöhnen, dann kann der Ekel sich gegen einen selbst richten. Und aus Ekel vor seinem eigenen Tun kommt man in so einen Rausch hinein und schlägt so lange zu, bis diese Person tot ist, sich nicht mehr bewegt, nicht mehr stöhnt." 144. [From a psychological perspective it is naturally also very understandable, that a person would fall unwillingly into a kind of murderous frenzy. When a person has just beaten someone, and her victim of the beating collapses from weakness, begins to bleed, to groan, then a revulsion can be directed back towards oneself, namely the person who has perpetrated the beating. And then, out of revulsion about one's own deed one becomes so repulsed that he or she continuous beating the victim until the victim no longer moves, no longer groans.] She cites as typical examples Hermine Böttcher 102 and Charlotte Mayer 107ff.

Zörner, G. 104-114. Zörner describes in detail the inhumane punishment imposed for even minor offenses. Women had to stand at attention for up to 9 hours in freezing cold, food was denied them, they were horsewhipped to death with studded sticks and whips, kicked with heavy boots, and attacked by vicious, specially trained dogs who tore apart their bodies. Often they were confined for days without food or water in dark rooms.

Aroneanu E, in his book, lists 130 accounts by eye witnesses of the atrocities committed by the guards. Aroneanu, E., *Inside the Concentration Camps. Eyewitness Accounts of Life in Hitler's Death Camps*, Westport: Praeger Publishers, 1996.

<sup>7</sup> Höss, R. 89.

National Socialism, all women were compelled to work and since more and more guards were needed in the concentration camps, these women had primarily been inducted without their consent.

The approximately 20,000 concentration camps administered by the SS were basically divided into forced labor camps (e.g., Dachau, Buchenwald) and the infamous extermination camps (e.g., Auschwitz, Treblinka).<sup>8</sup> Conditions were equally inhumane in both types, and although systematic exterminations were not performed on an equally huge scale in labor camps as they were in extermination camps, the death rate was nevertheless very high in labor camps as well. Women were imprisoned in almost all camps, and consequently, almost all camps had female guards. The largest camp for women was the extermination camp Auschwitz-Birkenau, while the Ravensbrück camp, located 50 miles north of Berlin, was reserved exclusively for female prisoners.<sup>9</sup> This camp served also as a training camp for female guards. Practically all guards employed in other camps were trained in Ravensbrück, initially by experienced women before they were assigned to other camps. Approximately 5000 women<sup>10</sup> were employed as SS guards until the end of the war in May 1945. In addition, tens of thousands of female prisoners were engaged as assistants to the SS guards, many of whom were more cruel than their superiors, the SS women.<sup>11</sup>

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<sup>8</sup> In extermination camps, more than 3 million prisoners, primarily Jews, were systematically murdered. Almost immediately after their arrival by train, the prisoners were cremated in the infamous gas chambers after their clothes and belongings had been confiscated by the guards. In the labor camps, prisoners, including prisoners of war, were used as slave labor. The high death rates in these camps resulted from execution, starvation, disease, exhaustion, and physical brutality. See Wiegrefe, K. "Die Schande nach Auschwitz." *Der Spiegel*, 35 (August 25, 2014), pp. 28-35.

<sup>9</sup> Apel, L. *Jüdische Frauen im Konzentrationslager Ravensbrück 1939-1945*. Berlin: Metropol Verlag, 2003.

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<sup>10</sup> According to Zörner and others, 3500 female guards were trained in Ravensbrück. 30.

<sup>11</sup> Kretzer cites as an especially vicious privileged inmate Carmen Maria Mory, who was regarded as "the most feared woman in Ravensbrück" and "the black angel of Ravensbrück." She was condemned to death but before her execution committed suicide. 118, 131, 155, et al. See also "Ravensbrücker Mory-Taten: Vera hat ein schlechtes Gewissen." *Der Spiegel* No. 4 (January 1, 1947); "Der SS-Staat: Die Henker aus dem Totenwald." *Der Spiegel* No.16 (April 19, 1947); "Rudolf Hoeß." *Der Spiegel* No. 15 (April 12, 1947).

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Benz, W. and Distel, B. Eds. *Der Ort des Terrors, Geschichte der nationalsozialistischen Konzentrationslager*. München: C.H. Beck, 2006. Vol. 4. 488-492.

One particularly gruesome incident at the Auschwitz sub-camp remembered by Percy Broad and reported in the appendix of *Death Dealer*<sup>12</sup> illustrates the extreme cruelty of these privileged prisoners. The block seniors, privileged inmates, in this sub-camp were former German prostitutes some of whom slept regularly with the male guards. These prostitutes had been placed in charge of about 400 Jewish,<sup>13</sup> Polish, and Ukrainian female prisoners. The guards had encouraged the German prostitutes to mistreat the Jewish women. If they refused, they themselves were forced to run the gauntlet between rows of howling SS guards, and if they attempted to escape this punishment, they were shot. By the men, this was considered a diversion to fill the boring guard duty with fun activities. Although the German prostitutes were paranoid that the Jewish women would somehow, somewhere, get even for the mistreatment, they complied with the request of the guards rather than be mistreated themselves.

On the evening of October 5, 1942, a German block camp senior thought that a Jewish woman was carrying a stone in her hand. She screamed that she had been hit in the head with a rock by the Jewish woman, and a bloodbath ensued. As the guards rushed to her “defense,” they started beating the Jewish women. The German female Kapos (inmates who had been assigned by the guards to torture other inmates) joined in, and one of them, Elfriede Schmidt, took an axe and split open the skull of a terrified prisoner. When some women in total panic tried to escape by crawling under the barbed wire fence, they were struck and brutally killed on the spot. Even when all the women lay helplessly on the ground, the fiends, drunk with bloodlust, kept on beating the helpless victims. In the end, they tried to kill everyone so that no witnesses would survive.

The next morning, a criminal investigation committee reported on the scene: “They witnessed a sight so horrible that what they were seeing did not immediately register in their minds. The area was covered with dozens of mutilated and bloody female corpses... Half-dead women were twisting in pain among the dead bodies. Some of the corpses hung in twisted positions in the barbed wire fence.”<sup>14</sup> They had obviously tried to escape. Although this may be one particularly gruesome incident, there were thousands of similar crimes committed at random by female SS guards and their privileged helpers.

<sup>12</sup> Höss. 333-335.

<sup>13</sup> “The Jewish female prisoners were, for the most part, well-educated. Some had attended the famous Sorbonne University in Paris, and some were artists who never even thought of stooping to the low-class level of the German prostitutes.” Ibid. 334.

<sup>14</sup> From the “Reminiscences of Percy Broad,” as cited in Höss, R. 334.

## What was the background of these female guards and how were they recruited?

In the late 1930s and especially during the war, women were compelled to work. The SS appealed to women ages 21 to 45 years with generous offers of financial compensation and social security benefits.<sup>15</sup> They had to be physically fit, “socially competent,” and politically reliable, i.e. accepting Nazi ideology and racial doctrine. They were offered underwear, shoes, attractive uniforms, and the possibility of rank advancement. Such offers were particularly attractive to women in the totalitarian state who had already served as leaders in the uniformed female branches of the Hitler Youth and the subsequent work organization (Arbeitsdienst) and had been thoroughly indoctrinated into National Socialist dogma there.<sup>16</sup> They were told that their duties consisted of guarding women who were incarcerated on account of their “infringements” (Verstöße) against the “people’s society” (Volksgemeinschaft) and to prevent them from causing further harm to society they had to be isolated.<sup>17</sup>

The assignments, so they were told, were “not strenuous,” consisted of “easy guard duty,” and did not require absolved vocational training. At first, a sufficient number of women volunteered for this apparently attractive assignment. Later, the SS inducted thousands of women primarily from the armament industry. Women were glad to exchange hard labor, long hours, strenuous working conditions, and small pay for what was advertised as easy work. Besides, the pay was triple or quadruple the pay in industry.

The applicants largely came from the lower classes, had little education, were physically fit, and despised Jews and foreigners,<sup>18</sup> and they were certainly aware that most inmates were intellectually and morally superior to them. Critics emphasize this fact, “die SS-Frauen spürten das selbst und bemühten sich, dieses Gefühl durch besondere Strenge und Grausamkeit zu verdrängen.”<sup>19</sup> [The SS-women felt that themselves and tried to repress these emotions by increased strictness and cruelty.] But the six-week training course at the concentration camp of Ravensbrück that the majority of them had to undergo trained

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<sup>15</sup> Strebel, B. 67.

<sup>16</sup> Zörner, G. 30.

<sup>17</sup> Erpel, S. Ed. *Im Gefolge der SS: Aufseherinnen des Frauen-KZ Ravensbrück*. Berlin: Metropol, 2007. 30-31.

<sup>18</sup> Müller-Münch, I. 102. Also Zörner, G. 31 and Tillion, G. 69.

<sup>19</sup> Zörner, G. 31.

them to have the necessary view of the prisoners. While the hard-core personnel enjoyed this training, those of a more sensitive nature were quickly and brutally awakened from their romanticized notion of a dream job. For them, it was too late, and they had to bend and adjust to the new realities.<sup>20</sup> Generally, they were not allowed to resign but were indoctrinated to believe, through regular training courses, that these inmates were not human beings but the “Abschaum,” the dregs of society from which the German people had to be protected. Some records remark how quickly even these more sensitive women adjusted to the vicious camp routines. After only four days, at the most after two to three weeks, they had learned to scream at the inmates, beat them, and mistreat them.<sup>21</sup> If they did not learn quickly, they were severely punished themselves. One particularly dreaded punishment was the so-called “Strafversetzung,” the transfer for disciplinary reasons to a death camp in Poland, like Majdanek or Auschwitz, where these female guards were a vast minority among hundreds of SS men and often exposed to their unwanted advances. Here, to prove their toughness, they often exceeded the brutality of the men when they were working alongside the male guards or SS officers. The heavy army boots they wore made them step like their male partners; in fact, their strides could no longer be differentiated from those of the men. Highly educated women were, according to the most recent research, not camp guards. They were not inclined to perform these kinds of duties, and because of their educational background, they were probably needed in more sophisticated employment.

Space, of course, does not permit me to report the background information of all 5000 guards. Moreover, information on all of them is not available. I will, therefore, mention just a few of the most notorious *Aufseherinnen* (overseers), as they were called, and generalize from them that many others had similar backgrounds and committed similar crimes. Based on the accounts we have, we at least know that all of them screamed their commands and insults at the inmates and punished them by beating them, although only a minority committed the most heinous crimes.

Maria Mandl was born in 1912 in Austria. Her father was a shoemaker, and she attended only four years of primary school before quitting to start working. After that, she drifted from job to job until she moved to Munich where, in 1938, she joined the SS, later joined the Nazi party, and finally started as a guard in Lichtenberg. The next year,

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<sup>20</sup> Benz, W. and Distel, B. 498.

<sup>21</sup> Tillion, G. 69.

she was transferred to the new women's camp in Ravensbrück where she quickly advanced in rank because of her cruel treatment of the prisoners. In 1942, she became SS-Oberaufseherin and then the top-ranking female SS officer in the extermination camp of Auschwitz-Birkenau. After the war, she was captured by American forces in Bavaria and extradited to Poland. The feared so-called "Beast of Birkenau" was convicted of having personally selected half a million women for death in the gas chambers, taking special pleasure in selecting children, and killing many adults and children herself. Witnesses described her as being exceptionally cruel by repeatedly hitting inmates in the face, kicking them with her boots, whipping them, and setting dogs on them. One witness stated that hundreds of inmates were so cruelly treated by her that they died. The Supreme Court of Cracow condemned her to death by hanging. She died on January 24, 1948, in Cracow, pleading her innocence to the last.<sup>22</sup>

Hildegard Lächert is reported to have beaten both men and women mercilessly. "Joyfully she kicked men into the groin and when they were lying on the ground she kept stomping on them." One survivor reported, "She had iron balls in her whip and metal points on her boots. Once I saw how she brutally tore apart an inmate with her whip and her boots,"<sup>23</sup> concentrating her kicks on face and genitals. Often, she would set her vicious dogs on the inmates. She seemed to have enjoyed seeing blood, often having blood on her boots, and was given the nickname *Bloody Brigida*. She spent years in a Polish prison, and later an additional 12 years in a German penal institution.

Irma Grese was born on October 7, 1923, in a little village in Mecklenburg. She had four brothers and sisters. Her mother died in 1936, and her father, a farmer, was apparently a strict man who performed corporal punishment. At age 15, Irma left school and started working, first on a farm, then in a dairy, and later in a hospital. When she was merely 18, she was trained as a camp guard in Ravensbrück. In 1943, at age 20, she was transferred to the notorious death camp of Auschwitz, where she quickly rose to the rank of Senior SS-Supervisor in charge of 30,000 female Jewish prisoners. Her trainer was Maria

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<sup>22</sup> Erpel, S. 49-58. See also Strebel, B. 75.

Müller-Münch, I. 74-88. Die Aufseherin Lächert "peitschte einmal einen Häftling, der mit Bodenarbeiten beschäftigt war, so lange und trat, bis er nur noch ein Fetzen von einem Menschen war, ein Klumpen Fleisch. Anschließend soll sie den umstehenden Häftlingsfrauen befohlen haben: <Schafft den Dreck da weg>" 77. [The guard Lächert once whipped and kicked an inmate who was working on repairing the road, until he was merely a scrap of human, a lump of flesh. After that she is reported as having ordered the women standing next to the dead inmate: "Get rid of this pile of dirt."]

<sup>23</sup> Ibid.

Mandl, whom she equaled in torture and murder. She was notorious for performing acts of pure sadism—whipping and stomping prisoners to death, arbitrarily shooting them, setting her half-starved dogs on them, and selecting them for the gas chambers. She wore heavy boots and carried a whip and a pistol. After the war, lampshades made of the skins of inmates were found. She was apprehended, convicted, and hanged on December 13, 1945, when she was only 22 years old!<sup>24</sup>

Ilse Koch was born on September 22, 1906, in Dresden. Her father was a factory foreman. She left school at age 15, learned accounting, and became a bookkeeping clerk. In 1932, she joined the rising National Socialist Party and befriended members of the SA (Sturmabteilung, the National Socialist Brownshirts) and the SS. There she met Karl Otto Koch in 1934 and married him in 1936 when he was Commander of the Concentration Camp Sachsenhausen where she served as camp guard. In 1937, Karl was promoted to Commandant in Buchenwald where she soon became Chief Female Overseer and was called the “Beast of Buchenwald” for her sadistic crimes. Witnesses accused her of selecting prisoners with tattoos on their bodies for the gas chamber so that she could graft their skin for lampshades and gloves after their execution. She stole hundreds of thousands of German Marks from prisoners for her private enrichment. She had two sons; one committed suicide after the war when he learned of the crimes of his parents and the other was illegitimate. She was convicted of incitement to murder and of committing grievous bodily harm, and she was sentenced to life imprisonment. In September 1967, she hanged herself in her prison cell.<sup>25</sup>

Hermine Braunsteiner was born on July 16, 1919, in Vienna, Austria. Her father was a teamster for a brewery, her mother a washerwoman. She was the youngest of seven children, attended grade school for eight years, and hoped to become a nurse. The family could not afford the training, so they instead encouraged her to work as a nanny for an aristocratic family. During the next few years, she continued doing menial work for low pay until after the “Anschluss” (the accession of Austria to Germany), when she found work in the armament factory. From there, she was recruited to become a camp guard in Ravensbrück and was trained by the notorious Mandl. This assignment appealed to her because of the “easier” work, the pretty uniform, and the much higher pay. She quadrupled her income.

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<sup>24</sup> Erpel, S. 103-106, 108, 111.

<sup>25</sup> Kretzer, A. 42, 136, 356, 388, 395.

After three years, Braunsteiner was transferred to the extermination camp Majdanek in Poland, where she was promoted to assistant overseer. Her abuses included tearing children from their mothers and selecting them for the gas chambers. According to witnesses at her trial, she "seized children by their hair and threw them on trucks heading to the gas chambers."<sup>26</sup> She whipped several women to death and killed others by stomping on them with her steel-studded jackboots, earning her the nickname "The Stomping Mare." For her particularly harsh treatment of prisoners, she was distinguished in 1943 with the War Merit Cross second class. After the war, she was sentenced to three years in prison and then granted amnesty in 1950, at which point she married an American and became a United States citizen in 1963. When Simon Wiesenthal discovered her a few years later, she was denaturalized in 1971 and, after long court procedures, extradited to Germany. A German court convicted her of the murder of 80 people, abetting the murder of 102 children, and collaborating in the murder of 1000. A sentence of life imprisonment was imposed (Germany does not have the death penalty). She served 16 years and then was released on account of severe illness; she died in 1999 at age 79.<sup>27</sup>

Cruel medical experiments were also performed on prisoners by male doctors and their crimes have been well documented. Some female physicians, however, also participated in medical experiments on inmates. As an example, I will cite the notorious Dr. Herta Oberheuser, who practiced in Ravensbrück.<sup>28</sup> She was born in Köln in 1911, studied medicine in Düsseldorf and Bonn, and received her medical doctorate in 1937 specializing in skin and sexually transmitted diseases. In 1935, she joined the female branch of the Hitler Youth and, in 1937, the Nazi Party. In 1940, she volunteered to work in Ravensbrück where she selected inmates for sulfanilamide experiments and bone transplants. In the Nürnberg Trials, she was convicted of having killed children with oil and Evipan injections and then removing their limbs and vital organs.<sup>29</sup> In August 1947, Oberheuser was sentenced to 20 years in prison but was released after five years for good behavior. After her release in 1952, she opened a family clinic but was identified by a survivor, and, consequently, her license was revoked. She died at age 66 in 1978.<sup>30</sup>

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<sup>26</sup> Wistrich, R. S. *Who is who in Nazi Germany*. New York: Psychology Press, 2002. 116.

<sup>27</sup> Müller-Münch, I. 89-101.

<sup>28</sup> Benz, W. and Distel, B. 507.

<sup>29</sup> For further details, consult Ebbinghaus, A. *Opfer und Täterinnen*. Nördlingen: Verlag Franz Greno, 1987. She reports the criminal activities of female doctors like Herta Oberheuser and Hilde Wernicke as well as of dozens of nurses in various camps. 218-273.

<sup>30</sup> Zörner, G. 116-118, also Strebel, B. 248ff. and Kretzer, A. 227ff.

Nurses in the camps appear to have been equally as callous as Dr. Oberheuser and the guards. Germaine Tillion reports that towards the end of the war in January 1945, a nurse by the name of Martha offered sleeping medicine to prisoners who had trouble sleeping at night. Many accepted the offer gladly but never woke up in the morning.<sup>31</sup> Apparently the “white insomniac powder” was used on a trial basis to expedite the murder of female prisoners. Tillion also reports that physicians as well as nurses performed abortions on all pregnant women in Ravensbrück: “If a child happened to be born alive, it would be smothered or drowned in a bucket in front of the mother. Since newborns seem to have a natural resistance to drowning, this procedure often lasted 20 or 30 minutes while the mother was forced to watch.”<sup>32</sup> Zörner reports that between 1943 and 1945, 870 children were born in Ravensbrück, all of whom died by freezing to death or starvation since the mothers could not nurse them and no food was provided for the children. Older children were murdered in the gas chambers.<sup>33</sup>

The nurses took orders from their superior, Oberschwester Elisabeth Marschall, who personally participated in all the crimes in the camp. She also personally selected the victims for the medical experiments performed by Dr. Gebhardt.<sup>34</sup> Nurse Erika is described as diabolical, nurse Lisa as mean-tempered and full of hatred, and nurse Martha as indifferently passing out poisonous pills.<sup>35</sup>

## What happened to these criminals after the war?

Only relatively few female guards were convicted by allied and German courts after the war. Some disappeared and were never found, some died of natural causes, others were found innocent for lack of proof. To find documentation that would stand up in court was nearly impossible. Records had been destroyed or were not kept on crimes in the camps. Eyewitnesses were few since most had been murdered. Testimony of survivors was frequently inadmissible because they could not recall precise details or correctly identify the guards.<sup>36</sup> Typically, in-

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<sup>31</sup> Tillion, G. 93.

<sup>32</sup> Ibid. 77.

<sup>33</sup> Zörner, G. 56-59. Also Benz, W. and Distel, B. 504-506.

<sup>34</sup> Tillion, G. 76.

<sup>35</sup> Ibid.

For a particularly detailed account of the activities of female doctors and nurses, consult the Ph.D. dissertation of Silke Schäfer. Schäfer, S. *Zum Selbstverständnis von Frauen im Konzentrationslager. Das Lager Ravensbrück*. Diss. Technische Universität Berlin, 2002. 86-163.

<sup>36</sup> Müller-Münch, I. 146.

mates had not been allowed to look at the faces of their tormentors but only at their uniform. They did not know the names of their guards since they were only allowed to address them by their rank. Cruel interrogation by defense lawyers, tolerated by the judges, confused the witnesses.<sup>37</sup> Finally, after many years of trials, the German population grew tired of hearing about the crimes, and the courts were reluctant to punish. The guards on trial routinely denied accusations or stated that they had to obey orders. If they had disobeyed orders, they stated, they would have been punished themselves. This assertion was true. In 1960, the statute of limitations concerning the majority of war crimes, like causing bodily harm and manslaughter, ran out.

In conclusion, we can only express our abhorrence at the inhumane treatment that millions of innocents received at the hands of tens of thousands of their fellow human beings. It is incomprehensible how a culture that produced the music of Mozart and Beethoven, the literature of Goethe and Schiller, and the philosophy of Kant and Hegel could have produced such subhumans as the concentration camp guards. That both men and women were capable of heinous acts and behaviors under the right conditions, and that even women, despite the stereotypes as the fairer and gentler sex, can become so abased that they can in some cases become more vicious than their male counterparts is incomprehensible to the rational mind. Although education and high social standing did not prevent men from rising in the ranks of the Nazi Party and becoming criminals, the story for most female guards appears to be the opposite. Indeed, the female SS guards behind the cruelest acts tended to be less educated and from a lower socioeconomic class. Thus, I would conclude that the history of the female SS guards is a strong reminder of the importance of education and economic parity for women as a means of helping them achieve their potential in making positive contributions to society that can lift, rather than debase, their fellow men and women.

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# Assessing the Observability of Hypernovae and Pair-Instability Supernovae in the Early Universe

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## ABSTRACT

*The era of the universe's first (Population III) stars is essentially unconstrained by observation. Ultra-luminous and massive stars from this time altered the chemistry of the cosmos, provided the radiative scaffolding to support the formation of the first proto-galaxies, and facilitated the creation and growth of now-supermassive black holes. Unfortunately, because these stars lie literally at the edge of the observable universe, they will remain beyond the reach of even the next generation of telescopes such as the James Webb Space Telescope and the Thirty-Meter Telescope. In this paper, we review recent work of the Los Alamos Supernova Light Curve Project and Brigham Young University to explore the possibility of probing this era through observa-*

*tions of the spectacular deaths of the first stars. Using radiation hydrodynamical numerical simulations, we find that many such brilliant supernova explosions will be observable as far back as ~99% of the universe's current age, tracing primordial star formation rates and the locations of their proto-galaxies on the sky. The observation of Population III supernovae will be among the most spectacular discoveries in observational astronomy in the coming decade.*

## 1. INTRODUCTION

Because the universe had a beginning, there must have been a first star. Supercomputer simulations now show that the first stars probably formed at redshift  $z \sim 20$ , or only 200–400 million years after the Big Bang in an event now called “Cosmic Dawn.” But star formation during this time was very different from what we observe in the universe today. The first stars formed in small pre-galactic structures known as cosmological halos, in pristine hydrogen and helium gases that were devoid of the heavier elements and dust that are ubiquitous in star-forming clouds today. A hypothetical telescope image of this time would not contain spiral and elliptical galaxies, but individual stars sprinkled through the universe's invisible dark-matter filamentary structure and slowly collecting in small stellar communities.

Because these stars were discovered most recently, they are called Population III (Pop III) stars; Pop III stars were created from only hydrogen and helium, and they would have had some unfamiliar properties. Clouds with this simple composition do not cool well, and this gave rise to truly gigantic stars that were hundreds of times more massive than the Sun and tens of millions of times more luminous (e.g., Hirano et al. 2014). A few may have been a hundred thousand times the mass of the Sun and may have been the precursors of supermassive black holes (Wise et al. 2008; Regan and Hehnelt 2009a). In a sense, one can think of this as the universe's very own Jurassic era where it manufactured *monsters*. These cosmological “dinosaurs” became extinct long ago as the first stars spewed heavier elements throughout the cosmos in spectacular supernova explosions. Chemically enriched interstellar clouds cool more rapidly and so are unable to grow to such large masses before collapsing to form stars. Thus, the modern cosmos is incapable of making the gigantic stars that may have been found in the primeval universe. Remains of this period likely persist today in the chemical composition of ancient, dim stars of the halos of galaxies.

It isn't merely the curious character of the first stars that fascinates cosmologists. The first stars populated the cosmos with heavy

elements, allowing for the later formation of planets and life. Their light also gradually transformed the universe from a cold, dark, featureless void into the vast, hot, transparent cosmic web of galaxies we observe today (Bromm et al. 2009). These stars and this period are key in resolving standing cosmological mysteries such as how super-massive black holes billions of times more massive than the Sun appeared less than a billion years after the Big Bang (Moretti et al. 2014). Primordial stars also populated the first primitive galaxies, which will be principal targets of the James Webb Space Telescope (JWST), which is slated to launch in 2018 (Bromm et al. 2009). Understanding the nature of the first stars is crucial to predicting the luminosities and spectra of primeval galaxies.

Unfortunately, these stars are beyond the reach of current observations. Individual primordial stars will not even be visible to the next generation of 30-meter class telescopes or space missions because they literally lie near the edge of the observable universe, when it was only 200 million years old. But the first stars may have died in luminous supernova explosions, and these spectacular events *may* be visible to upcoming instruments. Indeed, supernovae in the local universe can outshine their entire host galaxies and have now been detected as far away as 10 billion light years. With the coming telescopes, it may be possible to see even more distant explosions, which took place at Cosmic Dawn. These ancient supernovae (SNe) may offer the first observational constraints on this important but elusive and distant epoch of cosmic history.

To interpret the findings of future observations, cosmologists rely on predictions regarding the character, the luminosity, and the frequency of ancient SNe. In particular, cosmologists must know whether Pop III SNe are sufficiently luminous to be observable to upcoming instruments. Computer simulations are employed to provide models for the light curves (total luminosity as a function of time) and the spectra of these spectacular events. These will be used by observers to identify and characterize ancient SNe. Some types of primordial SNe have been modeled in the literature (see, e.g., Whalen et al. 2013a, 2013b, 2014b). In this study, we will investigate the observability of Pop III pair-instability supernovae (PI SNe) and hypernovae (HNe), which are types of brilliant supernovae explosions of very large stars. This era of the first stars in the universe may well have been the epoch of its most luminous supernovae if the first stars were sufficiently massive.

## 1.1 *How Big Was Big?*

Like deaths of stars in the local universe, the character (including the luminosity) of the explosive deaths of the first stars was primarily dependent upon their masses. The literature, however, has not always been in agreement on how massive Pop III stars actually were. Some studies suggest that they were tens of solar masses (e.g., Hosokawa et al. 2011), but others have found that some may have had masses of 500–600 times that of the Sun (e.g., Hirano et al. 2014). These estimates are largely based on simulations that attempt to follow the collapse and accretion of gas onto a protostar; however, no high-resolution simulation has evolved the protostar for more than a 1000 years, while the time between the formation and evaporation of its accretion disk may take *millions* of years (see Whalen 2012). Consequently, simulations cannot yet constrain the masses of the first stars.

Some properties of primordial stars can be inferred from the chemical abundances found in old halo stars in our own galaxy (see, e.g., Christlieb et al. 2002, Frebel et al. 2005). When the first stars died, ashes from their explosions may have been taken up in the formation of the next generation of stars. Joggerst et al. (2009) found that the cumulative nucleosynthetic yields of 15- to 40-solar mass Pop III supernovae are a good match to the elemental abundances measured in the extremely metal-poor stars to date. This finding would apparently contradict the results of simulations predicting Pop III stars of 100s of solar masses; however, “stellar archeology” as this study is called, is still in its infancy because of small sample sizes and the fact that the very metal-poor stars found so far reside in the galactic halo instead of the galactic nucleus, where most second-generation stars would be expected (Hirano et al. 2014). Most sources place Pop III stars as having between 50 to 500 solar masses. In modeling PI SNe and HNe, we are exploring the widely accepted paradigm that the first stars were very large.

## 1.2 *Hearts of Darkness and Hearts of Antimatter*

While less massive Pop III stars ended their lives as white dwarfs, neutron stars, or black holes, in some cases with core-collapse supernova explosions, massive Pop III stars would have died more exotically and spectacularly. Rakavy and Shaviv (1967) proposed that stars larger than 140 solar masses die in PI SNe. In these scenarios, core temperatures of the star during oxygen burning exceed about a billion degrees Kelvin, and thermal photons are converted into electron–positron pairs. This robs the core of radiation pressure, causing the core to contract and its temperature to rise. Explosive oxygen and silicon burning result.

Whereas less massive stars die with the *collapse* of their core, these stars' cores go up in a powerful nuclear explosion some 100 times more energetic than core-collapse supernovae. The energy release completely unbinds the star in a brilliant explosion. PI SNe synthesizes up to 40 solar masses of  $^{56}\text{Ni}$  whose subsequent radioactive decay can power the luminosities of these SNe for up to 3 years (Whalen et al. 2013a). The idea of a star with a core so hot that it creates antimatter may seem like science fiction, but a few PI SN candidates have now been found in the local universe (see Pan et al. 2012).

Previous studies have examined the visibility of 140- to 260-solar mass Pop III PI SNe to future telescopes (e.g., Whalen et al. 2013a), but new work has shown that rapidly rotating stars can encounter the pair instability at somewhat lower masses (Chatzopoulos and Wheeler, 2012). Rapid rotation mixes the star's layers and effects homogenous nuclear fusion throughout the star. This leads to a buildup of a larger oxygen core, which can trigger the pair instability at lower stellar masses. Lower-mass Pop III stars would have been much more common than their very high mass counterparts, and so we will investigate the observability of these newly discovered SNe.

Primordial stars between about 25 and 60 solar masses may die as HNe. These supernovae were not as energetic as PI SNe but were still luminous and likely sufficiently energetic to be observed in upcoming surveys. Although HNe have been observed (e.g., Nomoto et al. 1998), their central engines are not yet well understood. A prominent model is the collapsar model (Woosley 1993), in which the core of a rapidly rotating star collapses to a black hole surrounded by an accretion disk. Rapid infall onto the black hole drives a relativistic jet into the outer layers of the star, which are still collapsing. The jet breaks through these outer layers in a highly asymmetric explosion that is very luminous along the line of sight of the jet. fallback onto the star's newly formed and rotating "heart of darkness" powers these spectacular, beamed, events.

Finding these early cosmic explosions will open our first direct window on the primeval universe. If Pop III SNe are detected in sufficient numbers, the fact that distinct types of supernovae occur over different intervals of stellar mass could soon allow observers to determine how Pop III stars were distributed in mass. To some degree, the mass of the progenitor can be inferred from the light curve of its explosion. Primordial SN rates could also constrain star formation rates in the early universe. These events could also pinpoint the positions of primitive galaxies on the sky, especially if the galaxy is too dim to otherwise be detected. Likewise, the failure to detect Pop III SNe could imply lower star formation rates or less massive Pop III stars, either of

which would also be important discoveries. The observation of Pop III supernovae by future telescopes will be a landmark achievement in astronomy in the coming years.

## 2. METHOD

A thorough discussion of the Los Alamos Supernova Light Curve Project can be found in Frey et al. (2013). This source may be consulted for more technical details regarding our study.

We have modeled 12 PI SNe of rotating stars with masses from 90 to 140 solar masses in increments of 5 solar masses. We have also simulated six HNe. Observationally, hypernovae have been inferred to have explosion energies from 10 to 50 foe (Smidt et al. 2014), where 1 foe =  $10^{51}$  erg is the typical energy of a Type II SN. To explore the parameter space of likely Pop III HNe, we consider 10-, 22-, and 52-foe explosions of two hypernovae progenitors of 25 and 50 solar masses, respectively.

### 2.1 *Following Collapse and Explosion*

Our procedure differs in the modeling of PI SNe and HNe. We will describe the modeling of HNe and PI SNe in turn. Figure 1 provides a schematic that may assist the reader as we discuss our method below.

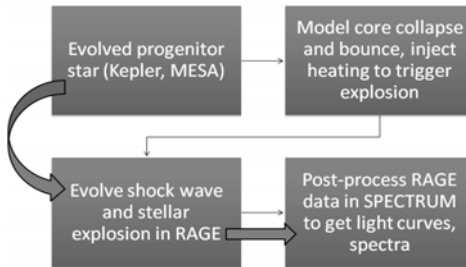


Figure 1. Schematic of our simulation process between various codes. To model hypernovae, we used the track indicated with the thin arrows as we needed to model core collapse and bounce and inject energy to trigger the explosion. To model pair-instability supernovae (PI SNe), we followed the track indicated with the thicker arrows as the explosion in PI SNe is emergent from the stellar evolution code. All simulations required RAGE and post-processing with SPECTRUM.

The energy and luminosity of a SN can depend strongly on the structure of the star prior to the explosion. To obtain the final profiles for the progenitor star, we evolve it from birth to the onset of collapse in the Kepler (Weaver et al. 1978) or MESA (Modules for Experiments in Stellar Astrophysics) (Paxton et al. 2013) stellar evolution codes. Because hypernovae are observed to be Type Ib/c SNe with no hydrogen lines in their spectra, we then strip off the hydrogen layer from both stars (recall we only have a 25- and a 50-solar mass progenitor) before transferring it to a one-dimensional Lagrangian core collapse code (Fryer 1999). This code follows the collapse of the star through the time when the core stops contracting and bounces, at which point energy due to neutrino absorption is artificially injected into the inner layers (the innermost 15 cells) to drive a range of explosion energies (see Young and Fryer 2007 for additional details on this code). We note that both stellar evolution and explosive nuclear burning must be modeled with extensive nuclear reaction networks that are self-consistently coupled to hydrodynamics to capture both energy production and nucleosynthetic yields. After nuclear burning is complete, which takes a few hundred seconds in the frame of the star, the HN is then evolved in Los Alamos' radiation hydrodynamics code RAGE (Radiation Adaptive Grid Eulerian) to follow the evolution of the shock wave as it travels through the star, bursts through its surface, and expands into the surrounding medium. The Kepler calculations require on the order of 24 hours on Los Alamos National Laboratory (LANL) platforms.

Our pair-instability progenitors were similarly modeled in Kepler and MESA, but there is no need to model core collapse and bounce or inject energy to drive the explosion. Pair production, core contraction, and explosive oxygen and silicon burning in PI SNe are emergent features of the stellar evolution model and do not have to be artificially triggered. Nuclear burning is usually finished in 10–30 seconds in PI SNe, after which it is transferred to RAGE.

Although RAGE can follow the evolution of SN flows and radiation coming from them, it cannot calculate light curves or spectra for the explosion (which are what would actually be observed by astronomers). To calculate the observational signatures of these explosions, we post process snapshots of the flow from RAGE with the Los Alamos SPECTRUM code. SPECTRUM calculates luminosities for the SN in 13,900-wavelength bins, which can then be summed to create light curves. SPECTRUM uses the LANL OPLIB (OPacity LIBrary) opacity database (Magee et al. 1995) to determine from which regions of the flow photons can escape to an external observer. SPECTRUM can also calculate the intensities of emission and absorption lines and take into account redshifting and blueshifting of photons due to relativistic ex-

pansion of SN ejecta. Spectra in the frame of the SN at very early times must then be cosmologically redshifted and subtracted by absorption in the intervening gas to determine light curves for the event in the Earth frame (“cosmological redshifting” refers to the stretching of photon wavelengths by the expansion of the universe over cosmic time as light from the event reaches Earth). The SPECTRUM runs required to calculate a single light curve require as many CPU hours as a RAGE run but can be executed in much shorter wall clock times because they can be run in parallel (usually only 1–2 days are required per light curve).

All the simulations in this paper are performed in one dimension and therefore exclude multidimensional effects that can break spherical symmetry such as hydrodynamical instabilities, magnetic fields, and turbulence. Our simulations also cannot capture orientational effects, which are thought to be important for some SNe. In some cases, mixing and dredging increases the luminosities of some events. Over large enough sample sizes, however, the simulations do give results sufficiently robust to estimate detection limits for Pop III SNe in redshift. Our SPECTRUM calculations (and the LANL OPLIB opacities on which they rely) also assume that matter is in local thermodynamic equilibrium, which may break down at later times when the supernova ejecta becomes diffuse. Our one-dimensional models of HNe also treat these highly asymmetric explosions as spherical events, but we inject enough explosion energy over the entire sphere to approximate the energy emitted along just the jet. Our simulations therefore should produce reasonable estimates of HN luminosities.

Our procedure for modeling hypernovae may raise the question “how sensitive are our results to be to the magnitude of the explosion energy injected through neutrino absorption?” Although no alternative to injecting energy over the whole sphere is possible in a one-dimensional hypernova simulation, we must consider how sensitive our results are to small variations in explosion energy. Our experiment is naturally set up to bracket this, as our six hypernovae explosions are created by varying explosion energy on only two progenitors from 10 to 52 foe. The variation in our results over a given progenitor will directly shed light on this issue. In general, we find that a twofold increase in explosion energy results in a twofold increase in peak luminosities.

## 2.2 *Evolution of the Supernova Remnant in RAGE*

After explosive nuclear burning is complete, output is fed to RAGE to model the radiation hydrodynamical evolution of the shock wave. The code captures the effects of radiating matter, which is in turn heated and accelerated by light. As the shock bursts through the surface

of the star in an event called “shock breakout,” light trapped behind the shockwave streams freely into space. The accelerating shockwave heats material surrounding the star to white-hot temperatures, setting it ablaze with light (see Figure 2). The grand effect is a sharp, brilliant pulse of light. The remnant can rebrighen at later times as radioactively decaying Ni-56 is exposed in the expanding remnant and heats the stellar material. All of these effects are modeled in RAGE.

The Los Alamos Code RAGE is an adaptive mesh refinement (AMR) radiative hydrodynamical code with a second-order conservative Godunov hydro scheme. It can utilize grey and multigroup flux-limited diffusion to model the flow of radiation. The RAGE simulations in our study have a root grid with 100,000 cells and allow up to 4 levels of refinement for up to 16 times more resolution. Opacities for radiation transport are derived from Los Alamos OPLIB database for the diffuse densities ( $\sim 10^{-20}$  g/cm<sup>3</sup>) typical of astrophysical scenarios. Although RAGE has three-temperature physics capability, in which ions, electrons, and photons can all have distinct temperatures, we use two-temperature physics, in which matter and radiation temperatures, though coupled, are evolved separately to better capture shock breakout. For details on RAGE, see Gittings et al. (2008) or Frey et al. (2013) for its application to supernova problems.

Since Pop III stars are thought to die in low-density HII regions (Whalen et al. 2004) but may be enveloped by a low-density wind following the expulsion of their hydrogen layer, we join a simple  $r^{-2}$  wind density profile with an initial density of  $2 \times 10^{-18}$  g/cm<sup>3</sup> to the surface of the star with an intervening bridge that has an  $r^{-20}$  density profile. The bridge mitigates numerical instabilities in the radiation solution in RAGE that would otherwise arise if the density at the surface of the star were abruptly dropped to that of the diffuse wind. We take the speed of the wind to be 1000 km/s and its composition to be primordial, 76% hydrogen and 24% helium by mass. When the wind falls to a number density of 0.1 particles/cm<sup>3</sup>, it is replaced by a uniform density profile similar to that of the ambient HII region.

RAGE runs require about 20,000 hours of CPU time on Los Alamos supercomputers and evolve the explosions out to three years.

### 3. RESULTS AND DISCUSSION

The total luminosity (energy/sec) as a function of time is plotted in Figure 3 for our HNe (upper panel) and some of our PI SNe (lower panel). Shock breakout is evident in all 11 events as the brief luminous

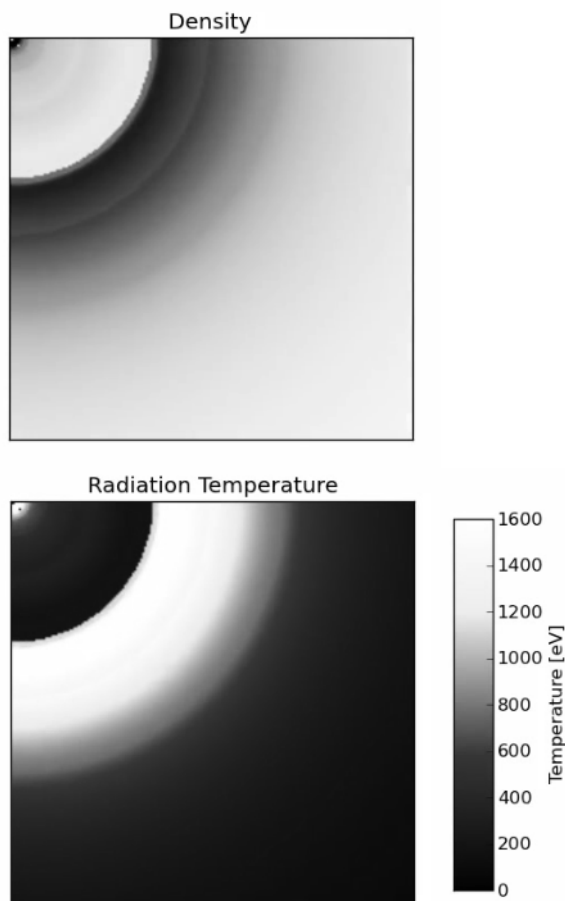


Figure 2. Snapshot of a RAGE hypernova simulation sometime following the moment when the shockwave breaks through the surface of the star and plows through the ambient medium. RAGE simulations are carried out in one dimension, so the extra dimension visualized here serves only to emphasize structure and provide a feel for the phenomenon. In the upper panel, relative density is indicated, black being regions with the most material. At this stage, the star has been almost completely disrupted into a ring (or a sphere in three dimensions) of glowing material. Matter has fallen back onto the central black hole (upper lefthand corner), which is radiating as observed in the bottom frame. Note that though the scale bar in the lower panel only indicates temperature up to 1600 eV, regions of this panel are tens of thousands of eV.

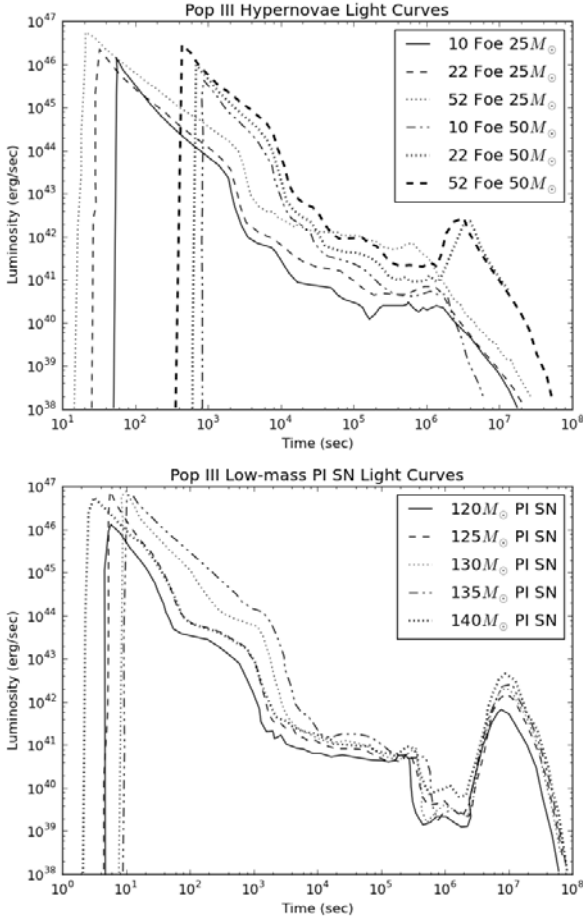


Figure 3. The upper panel contains light curves (total luminosity over all wavelengths as a function of time) for our hypernova runs. In the lower panel, we present light curves for the 5 most massive pair instability supernovae (120–140 solar masses). These light curves are calculated in the frame of the star (i.e., they do not account for cosmological redshift and obscuring gas along the line of sight). Note the bump in the light curves around  $10^6$ – $10^8$  seconds, which is due to radioactive decay of Ni-56.

pulse that lasts for about 1000 s (or about 20 min). They have about the same duration because the stars have similar radii. The peak luminosity increases with explosion energy. Although shock breakout is the brightest stage of the explosions, it will not be visible today. Most of

the photons at this moment are x-rays or hard ultraviolet (UV) that are absorbed by neutral hydrogen in the early universe before they can reach earth. Those that are not absorbed would be redshifted into the extreme UV by the time they reach the Milky Way and would be stopped in its outer layers. Rebrightening due to  $^{56}\text{Ni}$  decay is also visible in most of the light curves at 106–107 seconds, or at about 3 weeks to 3 months. The degree of rebrightening is proportional to the Ni mass, which generally scales with explosion energy. The least energetic SNe exhibit little or no rebrightening because they do not form much Ni.

Future observations will not measure the total luminosities of these events nor are these stars in the local universe, so Figure 3 by itself does not give us much information regarding how observable these events will be today. Observations will instead provide fluxes in specific observing bands in the near infrared (NIR) at 2–4 microns. Surveys will hunt for the first SNe in the NIR because any wavelengths in the rest frame of the SN that are shorter than those redshifted into the NIR today will be absorbed by the early universe.

We show NIR light curves for the 50-solar mass 52-foe HN and the 120-solar mass PI SN in Figures 4 and 5. It is clear that HNe will not be visible at redshifts beyond 10–15, or about 800 million years after the Big Bang. In Figure 5, we see that PI SNe with masses below 140 solar masses will only be visible at lower redshifts still ( $z \sim 3$ –8). While such events will not reveal the properties of the first stars, they will probe the stellar populations of the first galaxies, which form at these somewhat lower redshifts. Why are these highly energetic explosions only visible at much lower redshifts than only slightly more energetic 140- to 260-solar mass PI SNe, which can be detected in the first generation of stars? It is primarily because the progenitor has a lower mass and smaller radius at the time of the explosion. The fireball cools at earlier times (and hence smaller radii) and therefore is not as luminous in the bands that are eventually redshifted into the NIR in the Earth frame. We find that this is a general property of highly energetic explosions of compact Pop III stars (Smidt et al. 2014a, Smidt et al., in press).

Even if a telescope is sensitive enough to detect a primordial SN, there is no guarantee that it will actually come across one in its own lifetime. This depends on the field of view of the instrument and the number of events per square degree on the sky over some interval in redshift. The event rate in turn depends on the Pop III star formation rate. Telescopes like JWST are very sensitive but have very narrow fields of view. NIR missions such as Euclid and the Wide-Field Infrared Survey Telescope (WFIRST) are less sensitive but will survey

the entire sky. These instruments could, in principle, harvest large numbers of ancient SNe.

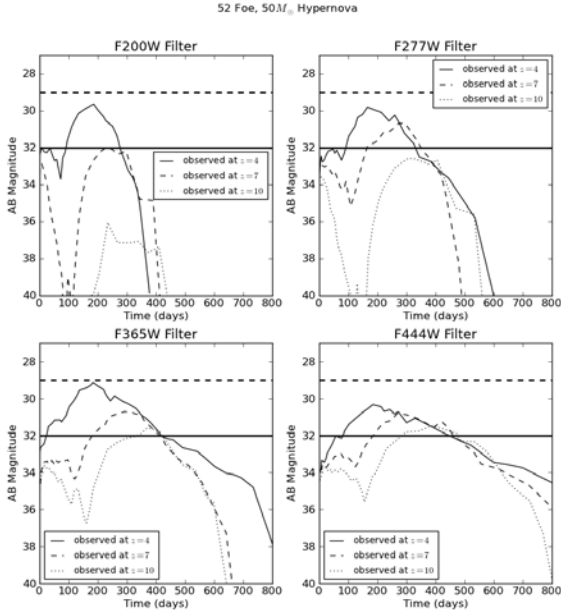


Figure 4. Light curves for the 50-solar mass 52-foe hypernova corrected for redshift and absorption by intervening neutral hydrogen from various redshift distances ( $z=4$  being the closest and  $z=10$  being the most distant). The different panels correspond to 4 NIRcam long-wavelength filters on the James Webb Space Telescope (JWST). The dashed horizontal lines represent the detection limit of Wide-Field Infrared Survey Telescope (WFIRST) after spectrum stacking, and the solid horizontal line is the detection limit for the JWST. This hypernova would, in principle, be visible out to  $z=10$  in some filters.

Perhaps the greatest challenge to detecting Pop III SNe is the low star formation rate during the era of the first stars. Another is that the first SNe are efficient at chemically enriching the early universe. A single PI SNe would spew its heavy elements deep into space, altering the chemistry of large regions of the universe, so there may be a relatively narrow window in redshift in which a SN can be guaranteed to be truly a Pop III event (Wise et al. 2011; Muratov et al. 2013). Both factors limit the total number of Pop III SNe on a given patch of the sky. In lieu of direct observations of Pop III stars, we must rely on cosmological simulations of early star formation for SN rates.

Unfortunately, differences in physics between the computer models can cause their predictions of star formation rates to vary by factors of 100

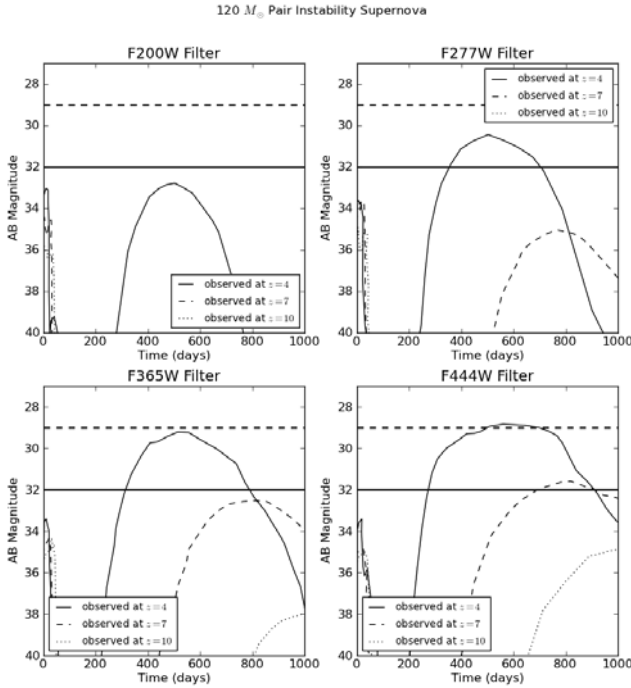


Figure 5. Light curves for the 120-solar mass pair instability supernova corrected for redshift and absorption by intervening neutral hydrogen from various redshift distances ( $z=4$  being the closest and  $z=10$  being the most distant). The different panels correspond to 4 NIRcam long-wavelength filters on the James Webb Space Telescope (JWST). The dashed horizontal line represents the detection limit of Wide-Field Infrared Survey Telescope (WFIRST) after spectrum stacking, and the solid horizontal line is the detection limit for the JWST.

or more (see Whalen et al. 2014a). In particular, Johnson et al (2013) found that HN rates could be as large as 1000 per year, with most occurring fairly late in the era of the first stars ( $z < 10$  or about 13.3 billion years ago). Campisi et al. (2011) found a more conservative estimate of about 100 HN events per year across this era. We note that even the failure to detect Pop III SNe in future surveys would be useful because it would rule out the cosmological models with the most optimistic star formation rates.

Could Pop III HNe be found by radio telescopes in surveys? Meiksin and Whalen (2013) have analyzed simulations of Pop III explosions in cosmological halos carried out with the ZEUS-MP code to estimate radio fluxes from HN and core-collapse SN remnants. They find that energetic HNe could be as bright as a few microJanskys in the L and 3-GHz bands, well within the detection limits of existing radio telescopes such as eMerlin and the Jansky Very Large Array (JVLA). Back-of-the-envelope calculations reveal that as many as two radio HNe could be present in a square degree of sky at any given time. To achieve  $\sim 3$ -microJansky sensitivity in the L band requires the JVLA to dwell on a single region of the sky for nearly 100 hours. Roughly eight such episodes would be required to reject the claim of two hypernovae per square degree with  $\sim 95\%$  confidence, bringing the total project time for such an undertaking up to a staggering 800 hours on the world's premier radio telescope. Further, if a supernova candidate were identified, follow-up over the space of years would be required to uniquely identify the event as a primordial explosion. Such surveys are possible, however. We have recently begun collaborations with Chris Hales of the National Radio Astronomy Observatory, who is leading a capabilities test of the VLA with a 1000-hour survey on a single patch of sky in L band that will take place over years. The survey will achieve sensitivities that would otherwise only be attainable by future radio telescope arrays like the Square-Kilometer Array, which will be built in South Africa and be able to detect Pop III core-collapse SNe in addition to HNe. Efforts to find the first cosmic explosions could piggyback on such current surveys. The detection of a primordial supernova will be among the landmark achievements in astronomy in the coming decade.

#### 4. CONCLUSION AND FUTURE WORK

In this paper we have described recent efforts by the Los Alamos Light Curve Project to assess the observability of some types of primordial SNe. We have considered the PI SN explosions of compact 90- to 140-solar mass Pop III stars and 25- and 50-solar mass Pop III HNe. We find that these events, although highly energetic, will not be bright enough to be seen at Cosmic Dawn by next-generation telescopes but may be visible in the earliest galaxies. They will complement other types of Pop III SNe as probes of the primeval universe. However, HNe (and core-collapse SNe, but not PI SNe) might be found among the first generation of stars in the radio, and we are currently collaborating with astronomers at the VLA on a 1000-hour capability survey to find them. This survey will be done over several years and will be ideal for detecting and uniquely identifying the remnants of ancient HNe.

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# In The Name of God

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## **Abstract**

*This paper is a brief analysis of the current security situation in Pakistan and Afghanistan in the context of a holy war. The conflict is primarily cosmic in nature. The entanglement of religion and cultures within the region has created a unique social system that has blurred the lines between right and wrong, just and unjust, holy and unholy. Victory is impossible in such a conflict, which is why defeat is illogical. The conflict and related terrorism are a cocktail of religious as well as secular doctrines. If victory is not possible, then how defeat can be avoided?*

Bertolt Brecht, the German poet and playwright, wrote that “War is like love; it always finds a way.” The history of war is as old as the history of our species, but it has changed greatly during the last few decades. The coming wars will be civil, long, and with relatively quiet battlefields. We have come a long way from the battlefields of Rome, Waterloo, Gettysburg, and Somme. Today, we are living in the age of the fourth generation of warfare, where the enemies are not nations but entities. Where the laws of war and conflicts tend to lose their legality

and value, where the enemy might be everywhere but nowhere, where morals are interpreted with relative values and the personal interpretations of just and unjust are far more real than universal understandings of right and wrong. Adding religion to this equation opens up a new dimension within the already chaotic scene. Religion has come to the forefront of the post-9/11 world, especially in the arena of wars and conflicts. Today, “us and them” syndrome is generally not based on territory, regions, ethnicity, or political systems, but now, faith and belief is playing the most important and crucial role in drawing the distinctions and divisions within the global community. Almost all religious wars have a secular, territorial, or ethnic reason behind them, but religion is primarily used to draw the lines and fuel the fire.

Religion is supposed to be a contract between the people and a divine entity. Religions are divine constitutions, written by gods and accepted by men. The desirable end result generally common in almost all religions is the eternal life in paradise or a place similar.

Entry into the paradise is promised in return for following a list of do's and don'ts. Religions that have a hard time evolving with the ever-evolving society may put their very existence at risk, but on the other hand, religions that have some level of flexibility and the ability to evolve and stay compatible with changing times have a much higher chance of survival. In other words, flexibility and openness to outsiders may be one of the most important aspects of a religion, as far as the growth of that religion is concerned. Religions are an integral part of a society, especially in the past, when societies or tribes that were followers of some sort of a religion or faith had a higher chance of survival because religious practices created a level of discipline, which helped in the creation of organized resistance against invaders and increased production of those essentials that were required for a tribe or society to survive. This discipline was also effective in the expansion of territorial influence within the proximate regions and even beyond.

It should be remembered that almost all major religions have gone through various stages of internal evolution. Some of those periods are cherished and remembered with pride and love, but there are other periods and incidents that the followers of those religions hope and try to forget. When social identity and religious identity mix up in regions plagued with collective social pain and suffering, conditions are ripe for conflict and chaos, not only collectively, but individually as well.

The concept of Holy war or Jihad, especially against the colonial powers, did exist during the colonial periods, primarily within the colonies, which had large Muslim populations. South Asia was no exception, but the resistance movements against the British colonial powers had more nationalist rather than the purely religious sentiment. The

idea of a religious or holy war in today's world really gained momentum with the invasion of Afghanistan by the Russians in 1979. Afghanistan and Pakistan became the bulwark against communism. The tribal warriors fighting the war against Russia turned into the warriors of God. In those days, the word "Satanism" became synonymous with communism within that part of the world. The message was clear: any one fighting the Russians was fighting the great Satan, and those who died in this fight had bought a certain kind of real estate in heaven, and the so-called 72 virgins were waiting for them at the gates of paradise. The Vietnam episode was fresh in the minds of the military and civilian policy makers in United States, and this was the perfect time for a tit-for-tat reply to the Russians. The war that started then has never stopped. The players changed, the loyalties changed, the whole dimension of war changed, but the war is on, and people are still dying because of it.

The United States attacked Afghanistan in 2001 to punish those who were responsible for the 9/11 attacks. By 2003, a strong insurgency was active primarily within the Pashtun regions of southern and eastern Afghanistan, which soon spread to the adjacent tribal areas of Pakistan. The attack on Afghanistan by the United States and other related activities were bundled as the War on Terror. This improper title and classification was one of the most important and pivotal factors in opening the door for a colorful and divine role play into the equation. Many in the United States were declaring this action as not just a war in the regular context of conflicts, but on a grand divine scale it was being declared as a war against Satan. The world again became polarized, and all those involved were being reminded the lessons and glories of The Crusades.

There should have never been a War on Terror. It should have been an international law enforcement action against criminals who violate the national and international criminal laws by killing people and destroying peace. They are criminals, plain and simple. The 9/11 attack was not simply an act of war, but it was a criminal mass murder. It was an attention-grabbing action, and grand historical attention is what it got. It can be rightly called as an invitation to war, rather than an act of war, an invitation that the United States and its allies promptly accepted. It was a huge loss, not only for the United States, but for almost all the people of the world, because since then, everyone everywhere on this earth has in one way or another felt the after-effects of the response to 9/11. This is exactly what the criminal organizations such as Al-Qaida dream about, because they get noticed, gain the much-needed attention, and elevate themselves, within their own

minds, to a place much higher than ordinary human beings and a lot closer to God.

The concept of fighting in the name of God is not a new phenomenon; this concept is as old as religion itself. The primary objective of war is not just the death or destruction of the enemy, but there is always some sort of a favorable strategic outcome, disguised as victory. Sometimes even the victors have a hard time understanding and identifying the favorable strategic outcome because, perhaps during the fog of war, things got muddy and the objectives and goals lost their clarity and purpose, but this is not the case when it comes to holy war or wars fought in the name of God, at least on the fundamental level.

In simple terms, the primary motive of a holy warrior taking part in a holy war is to please God. The most common narrative followed by the holy warriors goes something like this, “the time each person spends on this earth is temporary, but life after death is eternal. There is nothing better than spending the eternal life in heaven and the only way to enter heavens is to please God.” So, eternal life in heavens almost always takes precedence over the temporary earthly life of constant pain and suffering. If the only way to enter heaven is through the pleasure of God, or in other words, the pleasure of God works as a bridge towards the gates of heaven, then this means that the holy war is a struggle to please God, which means that the war is being fought for divine ends, although the battles are being fought on Earth.

This brings us to the most important question, how to win this war, or what’s the meaning of victory in this kind of war? The question, whether a holy warrior won or lost his holy war, can only be answered when the holy warrior dies and meets God, that is when he will know his true fate or the real outcome of his Holy war. If he has God’s pleasure, then he won the war. If not, then he has lost the holy war, but by then it’s not possible for him to inform his fellow warriors regarding the true outcome of their war, which means that all his fellow warriors will have to go through the same process and find the truth themselves, by dying and meeting God. In other words, the victory and defeat of a holy war on earth is decided and judged in the heavens, so logically, such a war cannot be won on earth, and if it can’t be won here, then it can’t even be lost on earth, because victory and defeat are counterbalanced. This means that there can be no real victory or real defeat in the logical and natural sense of these terms. Such analogy turns the holy war into a never-ending war. Mark Juergensmeyer has called it the “Cosmic War.” In this war, the most important decisions related to the war are made in the Cosmos, not down here on earth.

In this kind of a conflict, the real war should be against war itself, because war is the real enemy here. The best way to win this war is to

make sure that the war doesn't happen. One side decides not to fight the war but use all other means to achieve a favorable strategic outcome. We as humans, especially those who believe in the divine entity, have always tried to read and understand the mind of God, according to our own very human characteristics, including but not limited to happiness, sadness, forgiveness, anger, rage, needs, and wants.

The question regarding the true holiness of the motives of a warrior cannot be logically answered because to answer it, we as humans will try to use our own understandings of reason and logic to reach a conclusion, which in most cases will lean towards our own beliefs and faiths. This means that a war and its warriors might be holy and unholy at the same time, if we use the famous paradox titled "Schrödinger's cat" by Austrian physicist Erwin Schrödinger. The scenario presents a cat that may be both alive and dead, depending on an earlier random event. Unless someone is aware of the real present condition of the cat in this thought experiment, the state of existence of the cat cannot be known. Here is how it goes; a cat is put inside a box, with some nuclear material, a radiation sensor connected to a hammer, placed above a glass cylinder full of poisonous gas. If the nuclear material starts to decay, the sensor will get active and the hammer will be triggered to strike and break the glass cylinder, because of which, the deadly gas will be released and the cat will be killed. The real thought experiment begins when the lid of the box with the cat inside is closed. The process of nuclear decay is so random, that it's almost impossible to predict when it will start, which means that it may start the very second the lid is closed or it may happen ten minutes later or even ten million years in the future. Since we cannot know the true state of affairs within that box, because the lid is closed, we can rightly presume the cat to be both alive and dead at the same time. Logically, it's not possible for something or someone to be in two different and opposite states at the same time, but Schrödinger's cat paradox puts logic behind this illogical conclusion.

We can rightly applying the above paradox to the position and status of a warrior who is fighting in the name of the divine. When such a warrior dies, no one can know if this warrior did truly die in the name of God, as a holy warrior, evident by the fact that God was pleased with him, or if he died as an unholy warrior, because of God's displeasure with him, because, logically, no one can take a peek into the heavens and come back to report the dialogue between God and the warrior. So such a dead warrior is in two states of afterlife at any given time, one holy and the other unholy, but we can never know for sure, because we don't have the power and authority to remove the lid and observe for ourselves.

In the end, I would like to summarize the idea that any war in the name of God or gods is supposed to be spread out not only into different battlefields, but into different dimensions as well. These wars are never-ending because the end can never be in sight, because of the fact that we as humans cannot look into the realm where the fundamental decisions regarding the beginnings and the ends of such wars are being made. Wars have changed greatly during the course of human existence, but the wars in the name of the divine have always been part of the human civilization in the same form and manner and will be part of our existence even until the time when there are only two people left on earth and one of them believes that his faith is true and superior to the other's.

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# **Behaviors, Motivations, Beliefs, and Attitudes Related to Bottled Water Usage at Weber State University**

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## **ABSTRACT**

*This exploratory study aims to better understand the prevalence of bottled water consumption by students, faculty, and staff at Weber State University in Ogden, Utah, and positive and negative consequences of that consumption. In this multi-method study, we conducted a survey, receiving completed questionnaires from 711 students, faculty, and staff. Additionally, we gathered campus bottled water sales data, participated in a trash audit, researched the disposal of the plastic bottles, and investigated the demographics of brands consumed on campus to determine their environmental footprint. Twice as many of our survey respondents preferred tap water over bottled water; both groups reported convenience and cost among their top reasons. While there is evidence of some economic benefit to the university from bottled water*

*sales, this study was unable to discover the exact amount. Our findings indicate there are more negative consequences from bottled water consumption (particularly the environmental footprint) than positive ones.*

## INTRODUCTION

In 2006, Salt Lake City Mayor Rocky Anderson sponsored a resolution at the U.S. Conference of Mayors, an organization that represents mayors from over 1,000 U.S. cities, calling for studies on the environmental impacts of bottled water. Mayor Anderson referred to bottled water in public statements as “the greatest marketing scam of all time,” and, in a letter to his administrative heads, he requested they cease serving bottled water at meetings (Gleick 2009, p. 149). Our study attempts to examine the representation of bottled water at our own public institution.

Weber State University (WSU) is located in Ogden, Utah, with a population of more than 25,000 students. In 2009, WSU released its 40-year Climate Action Plan, which details how the university plans to become carbon neutral by the year 2050 (WSU 2009). This plan does not mention the use of bottled water on campus. While the university does not directly emit any greenhouse gases from the consumption of bottled water, this activity may fall under the Climate Action Plan’s “Scope 3 Emissions,” which are defined as “all other indirect emissions—those that are a consequence of the activities of the institution, but occur from sources not owned or controlled by the institution” (p. 16). WSU has not examined bottled water usage on campus by students, faculty, and staff, the campus community members who are our targeted research participants. The goal of this multi-method, exploratory research project is to determine the prevalence of bottled water consumption on WSU’s campus and what the positive and negative consequences of that consumption are, including any effect on Scope 3 Emissions.

## LITERATURE REVIEW

The United States is the largest consumer of bottled water on the planet, despite having one of the cleanest and most developed tap water infrastructures. Americans spent approximately \$21.7 billion on bottled water in 2011, with total sales volume up 4.1 percent—increasing twice as fast as the American economy. Bottled water consumption is at its all-time high nationally, in 2011 averaging 9.1 billion gallons—or 29.2 gallons (around 222 bottles) per person (Fishman 2011).

A considerable amount of research has examined why people buy bottled water when tap water is available for free. In a survey of students by Cunningham et al. (2010), convenience was the primary reason for purchasing bottled water for 45% of those who responded. People are able to buy a bottle of water almost anywhere, so it is not necessary to carry around their own bulky container all day. When finished, the bottle is easily disposed of in the trash, so consumers do not have to worry about taking their own bottles home to wash (The Economist, 2007). Many also perceive bottled water as a healthy alternative to soda they might otherwise drink.

Other studies show that negative perceptions of tap water are a major determinant in why people buy bottled water. These perceptions are influenced by the wide array of information sources people encounter every day. Doria et al. (2009) found that tap water's taste, and the perceived risk associated with that taste, was one of the biggest reasons for buying bottled water. O'Donnell and Rice (2010, p. 268) found that college students "...who purchase bottled water are more likely to have higher trust in traditional institutions [religious and political leaders, corporations, and mainstream media] but have lower trust in environmental/science institutions, read the campus paper, are non-White, and rate bottled water more positively on safety/taste and convenience." Interestingly, Cunningham et al. (2010) included a taste test of bottled water compared with tap water in their study. They found that tap water was actually rated as better tasting overall, although the temperature of the water played a very important role in which water was chosen as better tasting. Cold bottled water was preferred over slightly less-cold tap water.

Even though chemical analyses show that tap water is often safer than bottled water (Doria 2010), and municipal systems test their water multiple times a day while bottled water companies are only required to test their water once a week at the most (Fishman 2011), negative impressions of tap water remain. The public is unaware of these details and/or do not feel like they can properly interpret the analytical results of complex scientific reports (Jones et al. 2007). Additionally, bottled water companies' marketing campaigns portray tap water as unsafe, while the companies' water is portrayed as natural and pristine. Interestingly, almost half of bottled water consumed in the U.S. is nothing more than filtered or reprocessed municipal water that is bottled by these companies and then sold for thousands of times the cost (Food and Water Watch 2010). One-hundred percent of Dasani's and Aquafina's water comes from municipal water, while several of Nestlé's bottle brands do as well (Jaffee and Newman 2013).

## *Energy Impact*

Bottling all this water and shipping it worldwide consumes extreme amounts of energy required to manufacture, clean, fill, process, label, and transport bottled water. Every liter of bottled water consumes between 5.6 and 10.2 million joules of energy, compared with just 0.005 million joules per liter of tap water (Gleick and Cooley 2009). Depending on how far the water is transported, Gleick and Cooley calculated that the whole process can require up to 2,000 times the energy required for producing the same amount of tap water. They determined that consumption of bottled water in the U.S. alone in 2007 required the energy equivalent of between 32 and 54 million barrels of oil, with about three times that amount of energy required for worldwide demand. While recycling the bottles could save some energy, most plastic water bottles are currently made from virgin polyethylene terephthalate (PET) (Gleick and Cooley 2009).

In 2008, the rate of PET plastic bottles recycled in the United States was only 27% (36 billion bottles) (NAPCOR 2008, p. 4). By 2011, the rate had only increased to 29% (U.S. EPA 2013). Of the roughly 2.4 million tons of PET plastic discarded every year in the U.S., between 26 and 41% is from bottled water (Clean Air Council, n.d.). In McCarthy and Shrum's study of inconvenience and importance of recycling (2001), they argued environmental beliefs and behaviors are affected by underlying value orientations about interactions with others (e.g., individualism and collectivism) as well as with the material world (locus of control). They concluded that individualism was correlated with perceptions of recycling as inconvenient, while collectivism demonstrated a positive correlation with the perceived importance of recycling.

In a study assessing influences on college students' green purchasing (e.g., buying products made from recycled materials and choosing environmentally friendly products), Kim and Choi (2005) found collectivism influenced beliefs in consumer effectiveness, which then positively affected green purchasing. Those with greater collectivism would be likely to expect others to be engaged in similar socially beneficial behavior, thus increasing their efficacy.

## *This Study*

In this exploratory study, we investigated the prevalence of bottled water consumption on campus, as well as the positive and negative consequences of this consumption. Here are our research questions and expectations.

1. What are the water preferences of campus community members (bottled or tap)?

Research Expectation: We expect to see relatively high bottled water use among campus community members, since the U.S. is the largest consumer of bottled water on the planet and that consumption is at an all-time high (Fishman 2012).

2. Why do consumers choose the type of water they choose?
  - a. Why do bottled water consumers choose to buy water when it is available for free?

Research Expectation: Based on prior research findings, we expect factors ranging from cost and convenience to health and environmental perceptions to be among the principal reasons. Prior studies also show that attitudes towards collectivism, individualism, and levels of environmental concern influence bottled water use decisions.

3. How much is spent on campus on bottled water?
  - a. Are there economic benefits for the campus from bottled water sales?

Research Expectation: We expect some monetary gain for WSU from bottled water sales.

4. How much waste is generated from bottled water use on campus?
  - a. What happens to that waste?
  - b. Are there economic costs for the campus from bottled water use?

Research Expectation: We expect to see a rate of recycling on campus close to the national average of around 30% (U.S. EPA 2013) and that discarded bottled water waste results in a degree of additional expense related to additional trash removal.

5. What brands of bottled water are consumed on campus, and what are the “demographics” of those brands?

Research Expectation: We expect to see a variety of bottled water brands that vary in the types of water sources, distances traveled, and locations of bottling.

## METHODS AND FINDINGS

To investigate these various questions, we employed a multi-method approach to our research. These methods included a survey, a trash audit, and collection and analysis of sales data as well as information from WSU Facilities Management (FM) and Energy and Sustainability Office (ESO).

Additionally, demographic information was collected on the various brands of bottled water consumed at WSU, which was then used to calculate a carbon footprint. In this section we describe both the methodology and the findings for each of these various methods.

## *Survey*

### **Methodology**

Student researchers designed a survey, developing a survey instrument to investigate the research questions. A survey allowed collection of data that could be analyzed statistically to provide understanding of motivations, beliefs, and attitudes about bottled water. The survey questionnaire contained closed-ended as well as open-ended questions and sought to establish: 1) rates of preference for either bottled or tap water; 2) reasons for respondents' preference; 3) sources of water actually consumed in practice; 4) perceptions of bottled water as compared with tap water (e.g., safety, flavor); and 5) brands of bottled water purchased.

To gather data from a sample of the campus community population in a relatively quick manner, the survey was administered online. The sample of survey respondents was selected as follows: At least two academic departments were selected purposively, according to size, from each of the university's seven colleges, so that roughly 300 students, faculty, and staff (combined) from each college were invited to participate in the survey. Because staff were underrepresented within the college departments, nonacademic staff divisions were selected purposively so that another roughly 300 staff were included in the sample. From this total sample of 2,400 students, faculty, and staff, we hoped to receive at least 500 completed questionnaires. While not producing a generalizable sample, this sampling method was designed to make this convenience sample as representative as possible.

After academic departments and staff divisions were selected, department and division secretaries were asked to distribute a recruiting e-mail to those affiliated with the department or staff division. The email included a brief description of the research and a link to the survey questionnaire. No incentives were given for participating in the survey by email. Our online survey was administered electronically through University Communications.

The survey was also available for students to take during the Environmental Ambassador's Trash Audit of the Shepherd Union Building via laptops, computers, and iPods for one hour on October 30, 2013. An incentive of a full-sized candy bar was given for those who participated in the survey during the trash audit.

## Findings

Out of the more than 2,400 invitations sent, 711 respondents completed the questionnaire, including 521 (73.3%) from students, 159 (22.4%) from faculty and staff, and 31 (4.4%) from individuals who did not indicate their status at WSU.

In considering the water preferences of campus community members (bottled or tap), only 28.7% of our respondents indicated that they prefer to drink bottled water, while 58% indicated they preferred tap water (from any of its various sources) and nearly 7% more indicated they prefer water they filter at home, which is also most likely tap water. Two percent indicated they had no preference between bottled water and tap water (Table 1).

<b>Preferred source</b>	<b>Frequency</b>	<b>Percent</b>
Bottled water	204	28.7
Tap water (water fountains, sink faucets, refill stations, etc.)	412	57.9
None	17	2.4
Home filtered	47	6.6
No preference	15	2.1
Miscellaneous	15	2.1
Don't know	1	0.1
<b>TOTAL</b>	<b>711</b>	<b>100.0</b>

To investigate why consumers choose the type of water they choose, respondents were asked the open-ended question, "What is your reason for choosing this source?" Through an iterative process of sorting the 689 responses into qualitative categories that emerged from the data, responses fell into eight broad categories, which allowed for quantitative analysis (Table 2). Over one-fourth of respondents who answered this question stated convenience was why they chose their source, whether bottled water, tap water, or other. Many included convenience along with another reason, such as cost or taste.

While most of the 20% listing taste as the reason for their preference simply said "Taste," "It tastes better," etc., others stated they did not like the taste of their non-preferred option. For example, one individual who preferred tap water said "Bottled water tastes unnatural or chemically treated to me and tap water usually doesn't." Alternatively, someone who preferred bottled water said "I do not like water out of the faucet!!! I refuse to drink it, it has an iron/metallic taste to it."

<b>Table 2. Frequencies: Reasons for Choosing Preferred Water Source</b>			
<b>Why choose source</b>	<b>Frequency</b>	<b>%</b>	<b>Valid %</b>
Convenience of water source	181	25.5	26.3
Cost	124	17.4	18.0
Waste/enviro. concerns	68	9.6	9.9
Safety/cleanliness/health	106	14.9	15.4
Taste	139	19.5	20.2
Have own reusable bottle	32	4.5	4.6
No preference	19	2.7	2.8
Miscellaneous	20	2.8	2.9
TOTAL	689	96.9	100
No response/unusable response	22	3.1	

About 18% of responses focused on cost, and 15% on safety, cleanliness, or health concerns about a certain source of water. Some stated their water of preference was filtered at the source, making it safer: "I feel like it's filtered better, so it's cleaner" and "I know it is purified. Gives me a better peace of mind." Others listed health benefits, such as "I have fluoride in my tap water and it is good for my teeth."

Other categories included concerns about waste or environmental effects (e.g., "Bottled water is wasteful of so many resources and creates waste that is often not recycled"); having their own reusable water bottle (e.g., "I carry a Nalgene bottle with me everywhere. It's cheaper and carries more fluid ounces"); no preference (e.g., "I don't have a preference. I will drink any water!"); and miscellaneous, which included preferring whatever water is cold (e.g., "As long as the water is cold, it tastes good to me. No need to buy it") and preferring what respondents grew up with (e.g., "I grew up drinking water from the tap. I don't like the way bottled water tastes").

We compared the reasons given by respondents who preferred tap water and those preferring bottled water. There were 574 respondents who preferred one or the other and told us why, 385 of whom preferred tap water and 185 bottled water (Tables 3 and 4). Responses given by respondents who preferred tap water fell into six categories, with the top three being convenience, cost, and waste/environmental concerns. Responses of those preferring bottled water fell into four categories, with convenience, safety/cleanliness/health concerns, and taste accounting for close to one-third each. It is interesting to note that convenience was a major reason for preference for both tap water users

<b>Table 3. Water Preference Reasons for Tap Water Users</b>		
<b>Why choose source – Tap</b>	<b>Frequency</b>	<b>%</b>
Convenience of water source	104	27.0
Cost	115	30.0
Waste/enviro. concerns	67	17.4
Safety/cleanliness/health	21	5.4
Taste	48	12.5
Have own reusable bottle	30	7.7
<b>TOTAL</b>	<b>385</b>	<b>100.0</b>

(27%) and bottled water users (34%). On the other hand, having one's own reusable bottle, or waste or environmental concerns, both named by substantial percentages of tap water preferrers, were not given as reasons for choosing bottled water.

There was a large difference in the percentage of bottled and tap users who cited either taste or safety concerns as the reason for their preference. Over 34% of bottled water users mentioned taste, while just over 12% of tap water users gave this reason. Similarly, 30% of bottled water users said safety was their primary reason for their preference, while only 5% of tap water users said the same.

The survey also helped investigate the amount of waste generated from bottled water use on campus. The 102 respondents who reported purchasing bottled water on campus were asked what they do with their empty plastic bottles. Of the 100 respondents answering that question, 50% indicated they recycle the empty bottles and 38% stated they reuse the bottles. Only 12% of these respondents reported they threw the empty bottles in the trash.

The questionnaire also asked what brand of bottled water respondents preferred, and 155 respondents named 16 brands. Only five brands were preferred by five percent or more of these respondents (Smart Water, Arrowhead, Dasani, Nestle's Pure Life, and Fiji).

<b>Table 4. Water Preference Reasons for Bottled Water Users</b>		
<b>Why choose source – Bottled</b>	<b>Frequency</b>	<b>Percentage</b>
Convenience of water source	65	34.4
Cost	2	1.0
Safety/Cleanliness/Health	57	30.2
Taste	65	34.4
<b>TOTAL</b>	<b>189</b>	<b>100.0</b>

## *Sales Data*

### **Methods**

To find out how much bottled water is sold at WSU and whether there are any economic benefits to the school from these sales, researchers collected campus sales data on bottled water. There were three areas for consideration: vending machines, campus stores, and the catering service on campus. Researchers met with the individual who oversees vending machine contracts on the Ogden campus and the Director of Operations for Sodexo (the company that operates both the campus stores and the catering service) at WSU, who explained most aspects of Sodexo's operations on campus.

### **Findings**

Coca-Cola has “pouring rights” for the campus and owns and operates 51 vending machines in WSU buildings. Although some of the machines do not sell bottled water (the exact number is unknown and changeable), most machines sell Dasani for \$1.25 per 20-ounce bottle. At the request of some students and faculty/staff, Pepsi has two vending machines on campus that sell Aquafina water for \$1.25 per 20-ounce bottle. Most vending machines are refilled 1–2 times per week, with machines in two buildings refilled up to three times per week because of a higher number of students. According to Coca-Cola, 6,888 20-ounce bottles of Dasani were sold from campus vending machines between November 2012 and October 2013, resulting in \$8,610 in sales of Dasani alone. Sales data from Pepsi were not available.

Sodexo sold 856 20-ounce bottles of Dasani (sold for \$1.69 in campus stores) during the month of September 2013, as well as 809 20-ounce bottles of Smartwater at \$2.09 each. They estimate sales through fall and spring semesters are usually similar. Thus, roughly 7,000–8,000 20-ounce bottles of Dasani are sold in one academic year, at a total cost of \$11,000 to \$14,000. Additionally, Sodexo sold 194 1-liter Dasani water bottles at \$2.29 and 90 bottles of 1-liter Smartwater at \$2.69 each at campus stores.<sup>1</sup> So, overall, roughly \$20,000 worth of bottled Dasani and Smartwater is sold each year through WSU's vending machines and campus stores.

Sodexo also caters events, meetings, and meals on campus that may distribute bottled or tap water. However, the hosting organizations

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<sup>1</sup> The only bottled water brands Sodexo sells through its campus stores are Dasani and Smartwater (Coke products).

order the catering services and all beverages (including water) directly from the retailers; Sodexo simply distributes them. We were told the majority of catered events primarily used tap water, with soda and juices coming in second, and bottled water being distributed rarely and usually in small numbers. Finally, Sodexo provides dining services on campus, and all meals include iced tap water rather than bottled water.

Although we were able to discover the quantity of bottled water sold on campus and the amount spent on it, we were not able to find out the profit on the sales nor whether and to what degree these sales actually benefit the university.

## *Trash Audit*

### **Methods**

To investigate the brands of bottled water consumed on the WSU Ogden campus (to consider the “demographics” of those brands), the amount of waste generated from bottled water use on campus, and what happens to that waste, we participated in a campus trash audit. Although these questions were also explored through other methods, the research team thought a trash audit would provide additional data and enhance the validity of the study.

This project analyzed the bottled water bottles discarded in two high-use buildings. Late one Wednesday morning, the contents of every trash receptacle in the heavy traffic areas of the buildings were gathered into one spot. A team of six student researchers “audited” the contents of each recycling receptacle; water bottles were separated from the remaining recyclable materials and placed into a separate bag (the rest of the recyclables were sent to recycling). The process was repeated with the trash receptacles, with the bottles harvested kept separate from those collected previously and the waste rebagged as landfill-bound garbage. Researchers documented brand and the amount of liquid in the bottles, if any. Bottles from garbage and recycle receptacles were tallied by different teams of researchers on separate tallying sheets.

### **Findings**

In the analysis of these data, of the 44 bottles retrieved,<sup>2</sup> only 36 were found in recycling bins; the remaining eight were found in the

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<sup>2</sup> Brands found included Arrowhead (8), Dasani (8), Kroger (7), Kirkland (6), Nestle Pure Life (4), Great Value (3), Western Family (3), SmartWater (2), Albertsons (1), Aquafina (1), and Niagara (1).

trash receptacles. This means over 18% of the bottled water bottles retrieved had been simply discarded as garbage.

Twelve of these bottles, seven of which had been landfill-bound, contained some amount of water including two full bottles. This is relevant because, while it is our understanding that remaining liquid in recycled bottles is emptied at the recycling center, any leftover water in landfill-bound bottles is trapped in the bottles in landfills (thereby wasting the water).

## *Facilities Management and the Energy and Sustainability Office*

### **Methods**

Researchers gathered information about waste collected on the WSU Ogden campus by meeting with a sustainability specialist at the ESO, part of FM. The researchers' objective was to obtain information on the amount of waste generated from bottled water use on campus, what happens to that waste, and whether there are economic costs for the campus from bottled water use.

### **Findings**

FM does not keep track of how much waste is generated from bottled water consumption; however, they do keep track of all waste generated, as well as recycling waste. For example, the recycled waste generated on campus (including from bottled water) in fiscal year 2013 amounted to 191 short tons, down slightly from the previous year.

The ESO/FM relies partially on trash audits for a general sense of where campus waste goes. Most of the waste ends up in the trash can; recycling rates on campus hover around 20%. A good portion of the waste that is thrown away could be recycled. Trash accumulated on campus is a cost to the university, as Weber State gets charged extra if a dumpster needs to be dumped more than once per week. Although WSU does not profit from the recycling, they are not charged for recycling pick-up either, creating a financial incentive to recycle bottled water bottles.

In talking with ESO/FM, researchers also gained information about the implementation of water bottle refill stations on campus, which may provide insight into why a majority of survey respondents prefer tap water. At least 17 refill stations have been installed on campus, and these appear to be instrumental in decreasing bottled water use. Automatic counters track the number of times containers are filled from this source of filtered water that is free to consumers. Although

the counters cannot track the amount of water distributed to personal containers because of varying sizes, it seems likely the refill stations have decreased bottled water usage on campus.

## *Demographics of Bottled Water*

### **Methods**

Student researchers compiled a list of bottled water brands preferred by survey respondents, those discovered in the trash audit, and those sold on campus. Using brand websites, online articles about bottled water companies, and information printed on the bottles themselves, researchers investigated the sources of water used in bottling, the purification process, and the bottling locations for each brand. Not only was this information of interest in itself, this was also a necessary step for determining the carbon footprint of these brands. The U.S. Food and Drug Administration requires companies to release information about their products, so their websites were often good sources of information. While some websites provided only vague information, some of the labels described more clearly the source(s), and sometimes the purification process, of the water. It was difficult to find some brands in local stores (to examine the labels); in these cases researchers had to rely on online information alone.

### **Findings**

Data were gathered for a total of 16 bottled water brands.<sup>3</sup> Many of the brands, including Dasani, Aquafina, Penta, Great Value, Niagara, and Nestle Pure Life, bottled water from municipal water sources. Smartwater, Voss, and Fiji, come from artesian wells or springs. The source of Arrowhead's water is mountain springs in southern California, and Evian reports their water comes from a glacier. However, Kroger, Kirkland, Wat-Aah, Western Family, and Alzola have vague, foreign, or missing information, so there are limited findings on these brands. Purification methods ranged from naturally filtered water and minimal filtering to reverse osmosis, vapor distilling, and "advanced filtration" methods. Most were bottled in the southwestern United States, including Utah, Colorado, and California. Other companies used water from more distant parts of the U.S. or from foreign countries in-

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<sup>3</sup> Alzola, Aquafina, Arrowhead, Dasani, Evian, Fiji, Great Value Purified Drinking Water, Kirkland Signature Drinking Water, Kroger Purified Water, Nestle Pure Life, Niagara Purified Drinking Water, Penta, Smartwater, Voss, Wat-Ahh, and Western Family.

cluding Norway, Fiji, southeastern France, and the Basque region of Spain (Advanced Refreshment, n.d.; Aquafina, n.d.; Arrowhead, n.d.; The Coca-Cola Company 2008; Environmental Working Group 2011; Glaceau, n.d.; Nestle Waters North America Inc. 2011, 2012; Niagara Bottling, LLC, n.d., 2013; VOSS Water, n.d).

## *Environmental Footprint of Brands*

### **Methods**

Gleick and Cooley (2009) determined the energy used to produce bottled water, including the estimated energy costs associated with the transport of both imported and domestic water from bottling source to point of entry to point of consumption. Using their methodology, after the demographics data were gathered for each brand, researchers estimated carbon footprints from the transport of some the most commonly consumed brands of bottled water at Weber State University as discovered through our sales data, trash audit, and survey.

For brands shipped from overseas, the distance from their source to the nearest major American port was calculated (<http://www.distancefromto.net>). The distances of European brands were calculated to New York, and the distance of the brand from Fiji was calculated to Los Angeles. These distances were multiplied by Gleick and Cooley's (2009) transportation energy cost factor of an oceanic cargo ship.<sup>4</sup> This yielded the energy used by the cargo ship for each ton (MJ/ton) of bottled water transported. For this report, it was assumed that bottled water would be transported over land via medium truck, so Gleick and Cooley's energy factor<sup>5</sup> was used for overland distances.<sup>6</sup> The distances between the port (if from overseas) or bottling source (if from within the U.S.) and point of consumption (Ogden) was multiplied by this factor, resulting in energy used by a truck for each ton of bottled water transported. These numbers were totaled, resulting in the total energy used for transporting a ton of water from its source to Ogden. To determine how much energy was used to transport a liter of water (a common size for bottled water), the total energy used to transport a ton of water was divided by 1018.32, the conversion factor for tons of water to liters (<http://www.conversion-website.com/volume/ton-water-to-liter.html>).

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<sup>4</sup> 0.37 megajoules per ton cargo per kilometer ( $\text{MJ t}^{-1} \text{km}^{-1}$ ).

<sup>5</sup>  $6.8 \text{ MJ t}^{-1} \text{km}^{-1}$

<sup>6</sup> Overland distances were calculated as the crow flies rather than by highway distances.

To calculate the amount of carbon dioxide (CO<sub>2</sub>) emitted, researchers first had to determine the amount of diesel fuel (used to power both cargo ships and medium trucks) used to transport each liter of water. The energy density of diesel fuel<sup>7</sup> was multiplied by energy used per liter of water transported, which yielded the amount (in liters) of diesel fuel used for each liter of water transported. A liter of diesel fuel emits about 2.68 kilograms of CO<sub>2</sub> per kilometer traveled (Davies, n.d.). Total carbon emissions (in kilograms) per liter of diesel were thus calculated by multiplying that factor by the liters of diesel fuel used to transport the water.

This result, the number of kilograms of CO<sub>2</sub> emissions, was then multiplied by 180 to simulate the carbon footprint one would contribute if one was to purchase a single 1-liter bottle a day during a 180-day school year. This number (of kilograms) was converted to pounds.

## Findings

If an individual purchased one 1-liter bottle of Dasani or Smartwater (the two main brands sold on campus) every day during a 180-day school year, they would be contributing to the release of approximately 192 pounds of carbon dioxide (see Table 5 for this and CO<sub>2</sub> emissions for other selected bottled water brands). That is roughly the same amount of CO<sub>2</sub> emitted by an average car driving from Weber State to Vernal, Utah.<sup>8</sup> The daily purchase of another popular brand, Fiji, would contribute to even more CO<sub>2</sub> emissions—roughly 287 pounds, or the equivalent of driving from WSU to Boise, Idaho (nearly 311 miles). Taking into account the sales data we found, we calculated that Dasani and Smartwater purchased at WSU contributes to the release of over 1,700 pounds of CO<sub>2</sub> every month. That is equivalent to driving that car over 1,800 miles, or roughly the distance from Weber State to Atlanta, Georgia. Again, these estimates are the carbon footprint contributed just from the transport of bottled water. We did not investigate the footprint from the processing and packaging of bottled water.<sup>9</sup>

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<sup>7</sup> 35.86 megajoules per liter of fuel (<http://water2energy.com/diesel-fuel.php>)

<sup>8</sup> The average fuel economy for all cars and light trucks in 2011 was 21.4 miles per gallon (U.S. EPA 2014)

<sup>9</sup> For consideration of these processes, see Gleick and Cooley 2009.

**Table 5. Carbon footprint from transportation for select bottled water brands<sup>10</sup>**

Brand	Distance traveled (km)		Energy used per L transported (MJ/L)	Lbs of CO <sub>2</sub> emitted*
	From source to port (overseas sources)	From port or bottler to Ogden		
Dasani	N/A	970.29	6.479	192.156
Smartwater	N/A	970.29	6.479	192.156
Arrowhead	N/A	917.07	6.124	181.616
Nestle Pure Life (Municipal)	N/A	614.26	4.102	121.648
Nestle Pure Life (Wells)	N/A	940.56	6.281	186.268
Great Value	N/A	59.20	0.395	11.724
Fiji	8868.07	970.29	9.701	287.715
Evian	6244.77	3166.14	23.411	694.312
Voss	7494.09	3166.14	23.865	707.774

\*For one 180-day school year at 1 L bottle purchased per day

## DISCUSSION

Our research findings give us some indication of how prevalent bottled water consumption is on the campus of WSU. While we found that only 29% of our survey respondents prefer bottled water to tap water, we also found there are substantial consequences to the bottled water consumption that occurs at WSU.

The reasons given for these preferences include, for those preferring tap water, cost, convenience, and waste/environmental concerns; and for those preferring bottled water, convenience, taste, and safety/cleanliness/health concerns, similar to prior research findings (e.g., Cunningham et al. 2010; Doria et al. 2009). This is of note, since tap water is often safer and is better regulated than bottled water (Doria 2010); additionally, our demographic study of brands consumed at WSU found at least six brands that use municipal—that is, tap—water.

Our study sought to discover potential benefits as well as costs for WSU from bottled water consumption. While we were able to ascertain

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<sup>10</sup> Note: These are likely conservative estimates. Travel distances are “as the crow flies” and do not reflect real driving distances. Also, in cases where bottlers had multiple sources listed, the closest location to Ogden was used.

that roughly \$20,000 worth of bottled water is sold on campus annually, unfortunately, because of limitations in the information we were able to obtain in our investigation of sales data, the benefits to the campus are uncertain, other than the reported convenience for those who prefer bottled water.

In terms of costs to the university, there appear to be two types. First, the financial cost of waste disposal: While the amount of waste generated from bottled water on campus is difficult to quantify, the trash audit revealed that much of the recyclable material on WSU's campus is going into the trash, including that from bottled water, and while WSU is not charged for its recycling, it is charged for trash removal. If our trash audit findings hold true for the entire campus community, the university is losing money in the disposal process of this recyclable material. Here, WSU may benefit from using a community-type or team approach in promoting recycling, since values of collectivism have been found to transcend the more individualist perception of recycling as an inconvenience (Kim and Choi 2005; McCarthy and Shrum 2001).

Secondly, there are environmental costs from the use of bottled water. Researchers' calculations show the consumption of bottled water at WSU contributes to the release of a significant amount of CO<sub>2</sub> emissions. While the CO<sub>2</sub> emissions from the transportation of bottled water do not come directly from the university itself, they add to WSU's Climate Action Plan "Scope 3 emissions" (WSU 2009). Much more CO<sub>2</sub> is emitted when looking at the whole production process of bottled water (see Gleick and Cooley 2009). If WSU wishes to be carbon neutral by 2050, the sale of bottled water on campus is something that should be reviewed and discussed.

### *Limitations*

While this research is able to address the prevalence of bottled water consumption on campus and some of the positive and negative consequences of that consumption, additional questions of interest were not fully answered or addressed because of the following limitations.

Our study was geographically constrained by time and distance. The time needed to adequately address all aspects of this study was not available to the researchers as the study was completed in one semester. Additionally, this study was conducted on WSU's Ogden Campus rather than all campus sites that comprise WSU. Because of these constraints, a considerable proportion of the entire WSU campus population was not represented.

It is often safe to assume those who respond to online surveys, especially surveys without incentives, are primarily those who feel

strongly about the issue of focus. However, the number of our respondents indicating their preference for drinking water is based merely on convenience rather than a strong feeling suggests our findings may be more representative than one might assume. Despite this, though, the use of a convenience sample means the findings of the survey are neither representative nor generalizable to the entire campus.

The trash audit audited trash from only two of WSU's many buildings. Additionally, the audit was done in the late morning and did not include a full day of trash and recyclables.

Some of the information we sought eluded us. We were unable to find out the amount of trash and recycling generated from bottled water usage at WSU, hence the cost of trash disposal is not known. While we learned that some revenue likely comes to WSU through the sales of bottled water, we were unable to find out what WSU receives from these sales, and so were unable to determine whether economic benefits of bottled water sales outweigh the cost of trash removal and the emissions costs that count against WSU's plan for carbon neutrality.

### *Future Research*

Future research could include conducting further statistical analyses with the survey data from this project, analyses we were unable to do because of time constraints. Additionally, it would be useful to work towards more representative data collection, particularly with survey work and trash audits. This would provide important information on the reliability of our present findings.

### *Conclusion*

This exploratory study sought to understand WSU's bottled water consumption and the impacts of that consumption. We found bottled water use may bring both positive and negative economic impacts to the university and is a significant contributor of Scope 3 Emissions. This study demonstrates the significance of WSU's bottled water use. Overall, it appears there are more negative impacts from bottled water usage than positive ones.

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# Planning for Dark Skies: Lighting Ordinances in the Intermountain West

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## **Abstract**

*Light pollution increasingly threatens dark night skies throughout the cities, towns, and parks of the Intermountain West. This light pollution not only hinders human views of the stars, but it also disrupts ecosystems and represents significant waste in energy as we light the night sky. Within the last decade, communities around the Intermountain West have made efforts to curb light pollution and conserve the night sky. We argue that municipal-level planning is critical to limiting light pollution and preserving dark night skies. Through a literature review, a survey of municipal lighting ordinances, and interviews with local planners, we will explore some of the ways that communities around the Intermountain West are acting to address the negative impacts of light pollution.*

Light pollution is defined as unwanted, excessive, or inappropriate outdoor artificial lighting. The International Dark-Sky Association

(IDA), a non-profit group dedicated to reducing light pollution, has defined light pollution and its different types as “any adverse effect of artificial light, including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste” (International Dark-Sky Association 2012, 4). There are four different types of light pollution. Light trespass, when light falls where it is not wanted, is not only a sign of wasted light, but can also be a source of conflict. Glare comes from excessive brightness that causes visual discomfort. Glare is a significant safety issue since poorly designed lighting can impact the ability of older people, whose eyes do not recover as quickly from being exposed to bright light, to see while driving at night. Clutter is often found in urban areas that have many light sources grouped together in confusing patterns (IDA 2012).

Light trespass, glare, and clutter all represent inefficient lighting, and all contribute to sky glow. Sky glow, or the brightening of the night sky over inhabited areas, can obscure all but the brightest stars in the night sky—thus robbing humans of the ability to witness the night sky. This is a result of different types of artificial lights like street lamps and other outdoor lighting fixtures. In the early years of electricity, street lamps came in three general shapes: globes, acorns, and lanterns. These “traditional luminaires are in fact among the most inefficient and light-polluting of all lighting systems” (IDA 2012, 81). Most of these lights can be found in downtowns, historical districts, and themed developments. According to IDA, fewer than 20% of the lumens emitted actually light the street the street lamp is on. The rest of the light goes skyward, wasting energy and causing light pollution (IDA 2012).

Each type of light pollution can have significant impacts on human health and safety as well as other wildlife and environmental impacts. Accordingly, the issue of light pollution is receiving significantly increased attention within the last few years with documentaries, popular press articles, and new books (Klinkenborg 2008; Cheney 2011). Ongoing academic research is also making connections between the loss of the dark night sky and negative impacts on human circadian rhythms, which compromise human health and immune functions (Chepesiuk 2009; Haim and Portnov 2013), as well as a host of ecological impacts such as impact animal and insect breeding and migration patterns (Rich and Longcore 2005; Tuxbury and Salmon 2005; Gaston et al 2012; Perkin et al 2014).

Human health and ecological impacts are amplified by the economic costs of light pollution. Research suggests that up to one third of all lighting in the United States is wasted. Globally, outdoor electric lighting makes up 8% of global energy use, with about 60% of that being wasted through unneeded, overlit, or poorly aimed lighting (IDA

2013). In the United States, estimates suggest that light pollution costs nearly \$7 billion annually when the costs of wasted energy and of mitigating the impacts on wildlife and health are included (Gallaway et al. 2009). Individual city governments and individuals pay the costs of overlighting the night (Henderson 2010).

This waste, or light pollution, is what we see when we look at nighttime satellite imagery. Light pollution is a global phenomenon, but it is particularly noticeable in some of the more developed countries in the world, such as the United States. Within the United States, light pollution is more noticeable in the more populous East and West coasts. There are also patterns of regions, such as the Intermountain West, that exhibit less light pollution. This varied geography of light pollution is not surprising, and the view of the globe and the United States at night highlights a complex mix of population density, availability of electricity, and development. In fact, some scholars have begun to use light pollution as an indicator to measure economic growth and urbanization rates (Florida et al. 2011). While some scholars look at light pollution as a sign of economic growth, other community members have assessed the energy waste, harmful impacts on human health, impacts on migratory patterns, and the loss of the night sky and have begun efforts to limit these negative impacts.

In theory, light pollution should be relatively easy to manage. The solution is to make more efficient use of lights by pointing them toward the ground and shielding fixtures so that the light is directed only at where the light is required. Innovative lighting practices and strategies can help home owners, business owners, and municipalities reduce light pollution, but in practice, as you might expect, efforts to reduce light pollution have been more complex.

To accomplish a sustained reduction of light pollution and conservation of the dark night sky, particularly in an urban setting, planning and community effort are essential. The IDA recognizes the importance of local policy and publishes a Model Lighting Ordinance that is designed to “develop outdoor lighting standards that reduce glare, light trespass, and sky glow” (IDA 2014). Having access to an effective model ordinance is not enough though, as local governments, planners, and citizens have differing needs and interests in relation to the night sky. How are amenity-oriented communities in the Intermountain West using the tools of land-use planning to control light pollution and conserve the dark night sky?

One element that is an important part of dark sky planning in the Intermountain West is the IDA's Dark Skies Communities program that is designed to recognize communities that have put planning measures in place to protect the night sky. Flagstaff, Arizona, was the first Dark

Sky Community. While the city did not receive official recognition until 2001, Flagstaff's protection of the dark sky resource goes back to the 1950s in order to protect the Lowell Observatory in the city. The Flagstaff Dark Skies Association states: "As the international dark sky movement began in Flagstaff in 1958, our community has always been keenly aware of the special value of the night sky" ([www.flagstaffdarkskies.org](http://www.flagstaffdarkskies.org)). This value is not just the intrinsic value of being able to see the stars, but has brought a real economic boon to the city. With a population of about 67,000 residents, Flagstaff is the largest city that has earned the Dark Sky Community designation. The IDA has other programs that are designed to recognize a variety of different types of dark sky efforts, including Dark Sky Parks for places with exceptional sky quality, such as Natural Bridges National Monument, which was the first International Dark Sky Park.

These communities recognize the negative impacts of light pollution and are trying to mitigate these impacts. In many cases, though, these communities are also attempting to capitalize on dark skies preservation as a resource—working to manage light pollution so that the dark night sky can be a selling point that can attract capital to the community. This type of amenity-oriented development seems to fit with one of the leading narratives of development in the Intermountain West that identifies a shift from economies of industrial and extractive production to economies of natural amenity consumption. While it is true that "nature is as central to capital in the West today...as it was in the nineteenth century" as Western scholars argue (McCarthy and Guthman 1998, 67), the kind of nature that attracts capital to rural communities is changing. In the contemporary economy, environmental amenities such as mountain biking trails, ski resorts, and perhaps amenities like a dark night sky are creating specific types of landscapes in the region. But as with any process of conservation or pollution abatement, preserving a dark night sky does not happen organically—it requires careful planning and community support.

Whether trying to aim for international recognition by the IDA or to limit light pollution in their community, small communities are using land use planning techniques to preserve the night sky. To examine these topics further, we needed to find examples of small communities that are planning for dark sky conservation in the Interior West. Through careful searches of land use ordinances and planning documents for cities in the seven intermountain West states (Arizona, Colorado, Idaho, Montana, New Mexico, and Utah), we identified the lighting ordinances of each community. Some of these were easy to locate online and contained detailed, several-page documents that outlined lighting zones, lighting types, curfews, lists of special exceptions,

and a host of other important information. Others were difficult to find, short documents and contained very little useful information. While most towns and cities have lighting ordinances that address the type and intensity of lighting that is allowable in the community, we focused on those cities whose ordinances are designed explicitly for dark sky conservation. Ultimately, we decided to look closely at Breckenridge, Colorado, the state of New Mexico, and Whitefish, Montana, as examples of planning tools that are in use in the Intermountain West. We then began talking with planners in these communities to fill in some of the gaps in our knowledge about the status of dark skies planning in the Intermountain West.

What follows are brief case studies from these areas that will highlight a few notable characteristics that can help us understand the role of dark sky planning in the Intermountain West.

## **Breckenridge**

According to our findings, the Town of Breckenridge, Colorado, has a very good lighting ordinance that was enacted in 2007. Dark sky conservation was an important rationale for the lighting ordinance. The ordinance states: "Because of the importance of the view of the stars in the night sky to the town's residents and visitors, it is important that the town adopt responsible lighting standards to preserve that view," and "preserving and protecting the night sky enhances the use and enjoyment of property through the use of appropriate lighting practices" (Town of Breckenridge 2007, §9-12-13). In addition to these value statements, the council found that appropriate lighting helped them conserve energy and maintain their small-town character.

Breckenridge effectively uses lighting zones to regulate the types of lighting regulations in place in different parts of the community. For example, the city created Lighting Zone 1 as the downtown zone, Lighting Zone 2 in the commercial area, and Lighting Zone 3 as residential. Each of these lighting zones makes allowances for particular types of lighting needs in each zone—for example the downtown zone allows for bistro lighting in outdoor dining in summer months (Town of Breckenridge 2007, §9-12-10). According to our research, lighting zones are an underutilized resource that allows communities to separate areas of the city that have different lighting needs. Lighting zones are one of the suggested elements of the IDA's model lighting ordinance that has not been adopted widely throughout the Intermountain West.

Breckenridge has also worked diligently to educate residents about the ordinance by providing clear examples of what kinds of fixtures are and aren't allowed. In addition to the text of the ordinance,

which many residents may choose not to read, the city has produced clear language pamphlets with diagrams and helpful resources that will help residents comply with the standards. In the estimation of one planner, the residents of Breckenridge have had more success adapting to the new ordinances than architects and builders have. With the ordinance in place for 7 years, one Breckenridge planner comments: "I believe the lighting ordinance has been a success. It has been hard for architects to get used to the change. Many architects were very used to picking out glass fixtures with semi-opaque glass, and they liked that look, the warm glow the house put off at night. However, our current ordinance requires fully opaque fixtures. I have had to down many proposed fixtures for not meeting the town's ordinance, but slowly the architects are figuring it out. I believe the community in general supports it, some property owners have had issues with the Town telling them they cannot use certain types of fixtures" (Town of Breckenridge Planner 2014). As communities in the region begin dark sky planning efforts, it is important to provide a framework for all interests to be able to adapt to new regulations.

Finally, the Breckenridge ordinance is prospective in that it applies immediately to all new development, remodels, or installation of new exterior lighting fixtures, but if residents and businesses already have lighting in place, they are a legal nonconforming use until 15 years after the ordinance was put in place (Town of Breckenridge 2007, §9-12-4). This timing is significant. While dark sky advocates often are eager to see more immediate change, our findings show that community opposition is less intense when residents are allowed to keep their lighting and plan for any changes they need to make.

## State of New Mexico

The state of New Mexico passed one of the first statewide Night Sky Protection Acts in the nation in 1999. This act came about after the New Mexico Heritage Preservation Alliance declared the night sky as one of the state's most endangered cultural resources. The organization says that the night sky program is dedicated to "preventing the loss of starlit skies that have inspired New Mexicans for generations" (New Mexico Heritage Preservation Alliance 2005). The Night Sky Protection Act does not rely on the concept of heritage to claim legitimacy, though, but instead claims the rationale for its creation is "to regulate outdoor night lighting fixtures to preserve and enhance the state's dark sky while promoting safety, conserving energy, and preserving the environment for astronomy" (New Mexico Heritage Preservation Alliance 2005). The combination of multiple purposes for dark sky lighting or-

dinances was an important part of many ordinances. The intrinsic value of a dark night sky, in many cases, was not enough of a rationale for a lighting ordinance. The values of safety or energy preservation or other more practical and tangible elements were an important part of many ordinances.

This statewide ordinance, though, is relatively weak because of the multitude of exemptions that it allows. It states that all outdoor lights need to be shielded—except for incandescent bulbs of less than 150 watts, or if your fixture was installed before the ordinance date, in which case you may continue to use your fixture for as long as it works. If you ever replace that fixture, though, the new fixture needs to be compliant. If you would still like to use a noncompliant fixture, you may, as long as it is off between 11:00 pm and sunrise. Finally, the New Mexico state ordinance provides an exemption for lighting on outdoor advertising signs—even though illuminated signage can be one of the biggest light polluters. With all of these important exemptions, the New Mexico Heritage Preservation Alliance concedes that, “while the law may not be as stringent as many had hoped for, it provides a framework that supports education and advocacy efforts. More than anything, it has brought the issue of light pollution to the attention of the general public and made it part of the consciousness” (New Mexico Heritage Preservation Alliance 2005). The hope, though, is that this ordinance, while weak, will create a framework for local governments to make their own ordinances for preserving dark skies.

## **Whitefish**

The city of Whitefish, Montana, introduced its dark sky lighting ordinance in 2006. As with most lighting ordinances we looked at for this project, the focus was on preserving the night sky, but the start of the movement to establish a more strict ordinance was one property owner with exceptionally poor lighting—in this instance, it was a local car dealership (City of Whitefish Planner 2014). This ordinance differs from the Breckenridge ordinance in a few ways. City officials attempted to foster community buy-in in many standard ways, such as creating a diverse ad-hoc planning committee and encouraging a lot of public input. A fairly unique approach to encourage this input came when the city was planning to replace some noncompliant streetlights on a downtown street. Instead of merely looking at pictures and imagining what the new fixtures would look like, the city took the extra measure of temporarily installing several dark-sky friendly street lights and held walking tours of the street so that residents could see examples of quality fixtures and select the fixtures that would eventually

illuminate downtown (Hintzet 2005; City of Whitefish Planner 2014). This practice had the dual benefit of allowing residents feel involved in the dark sky lighting process, as well as providing city decision makers the opportunity to see the fixtures in place and make a more informed decision.

An important part of the Whitefish ordinance is that it allowed residents and commercial businesses only three years to comply with the new standards. This time frame is significantly faster than Breckenridge's 15-year time frame and is perhaps one reason why now that the ordinance is in place planners say that enforcement is problematic. A local planner commented, "We aren't closely monitoring [compliance] and only respond to complaints. We have had some success with monitoring complaints, mostly with the commercial projects" (City of Whitefish Planner 2014). Code enforcement is a common concern for many dark sky lighting ordinances, and sometimes the non-compliant fixtures are even owned by the city. Whitefish has found that replacing street fixtures is expensive. A local planner said, "There are a number of noncompliant public lights in town that will take many, many years to replace. It would be good to get an inventory of these lights so the city could set aside money to start a lighting replacement program, but that hasn't happened, there are too many other priorities" (City of Whitefish Planner 2014). Even though the city has had some problems becoming compliant to its new ordinance, the ordinance has already shaped lighting in important ways. For example, when the Montana State Department of Transportation was updating lighting on the highway through the city, the city was able to negotiate with the state to install dark sky compliant fixtures instead of the standard lights that the state typically uses (City of Whitefish Planner 2014). Having the regulations in place helped to put the city in better negotiating position to shape its dark sky lighting.

## **What to Do Elsewhere**

What about communities in Utah? What kinds of lighting ordinances do we have in the state? The answer, as with most things, is that it is really a mixed bag. Utah does not have a statewide night sky preservation act comparable to New Mexico's, and there are relatively few local lighting ordinances that focus on dark sky preservation like those in Breckenridge and Whitefish. Some communities such as Park City have dark-sky lighting ordinances in place. The Park City ordinance states that "the enjoyment of a starry night is an experience that the community desires to preserve. The City of Park City promotes the reduction of light pollution that interferes with enjoyment of the night

sky" (Park City Municipal Corporation 2014). Additionally, Ogden Valley is currently in the process of revising its lighting ordinance to have both clearer language and a more explicit focus on dark sky lighting strategies. Also, with considerable support from Weber County commissioners and numerous community leaders, North Fork Park in Ogden Valley is on track to be certified by the International Dark-sky Association as a Dark Sky Park.

Ultimately in Utah, as in all places, the choices we make now will influence what our skies look like in the future. Consider the statement that accompanied UT House Bill 140 in 1996 when state legislators named the Beehive Cluster as the state's astronomical symbol. They said: "This symbol, composed of a hive of stars, transposes our beehive symbol to a new and grand level as we enter our second century as a group of people living in a place where we can still see, with our own eyes, the beautiful and dim features of the starry universe" (Utah.gov 2014). The stars in a dark night sky are surely beautiful, regardless of human influence, but how dim they become depends in part on the lighting ordinances we put in place to reduce light pollution and preserve the dark night sky.

## Conclusion

This paper has introduced a few case studies and identified some themes that can act as a beginning to more in-depth research into the impact and practice of planning for dark sky conservation. A more thorough survey of the landscape of existing ordinances would reveal greater insights into current best practices as well as identify areas of weakness that can be improved. Additionally, more interviews with planners, dark sky advocates, and community decision makers would reveal some of the common successes and pitfalls that are part of the dark sky planning process. Both of these pieces of information would help communities be more prepared to plan for dark skies through lighting ordinances.

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# Shall We Share a Ride, Wildcats? CVM Study of the Willingness of Weber State University Students to Accept Ride-Sharing

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## **Abstract**

*This article evaluates the willingness to accept (WTA) carpooling with binary logistic regression using the methodology of contingent valuation method. This study, a practical application of the work outlined in the previous empirical research ventures, measures how much Weber State University students are willing to accept the introduction of a car-sharing system with a detailed survey. To demonstrate the amount of WTA car-sharing, 5 different levels of compensation (\$0, \$25, \$50, \$75, and \$250) were offered respondents ( $n = 181$ ) enrolling for the current semester. The mean WTA was \$56.55, and the marginal effect of a main interested predictor, price, was 0.0013, meaning as one dollar increases, there is an increase in the possibility for a respondent to participate in car-sharing by 0.13%.*

## Introduction

Since the late 1970s, the air pollutants from rapid worldwide industrialization have increased. The main factor in increasing climate change is greenhouse gases, and the costs to resolve social and natural damages and recover air quality have resulted in a negative social welfare economically and sociologically. In the Utah area, Logan had the worst air pollution nationwide on January 15, 2004 (Malek et al. 2006). Overall, Utah's continuously serious smog problem can be reasoned to be caused by two main factors: fuel-burning and auto fuel consumption. The Utah Division of Air Quality has been trying to prevent air pollution from reaching unhealthy levels, especially in Salt Lake City, Weber, and Davis Counties (Maffly 2013). Strict regulations to prohibit wood burning have been introduced and residents have been provided with a free smart app giving alarms of real-time air quality to encourage people to stop burning voluntarily.

My question was whether there have been measurable efforts to cut down the amount of fuel burned to reduce the level of greenhouse emissions in Utah. There has not been any measure privately or officially to reduce auto fuel consumption, which is from a high number of cars emitting greenhouse gases on the road. This study tries to evaluate the willingness to accept (WTA) and/or willingness to pay (WTP) for a car-sharing system by Weber State University (WSU) students, who are mainly located in one of the Utah counties most seriously affected by a dangerous level of air pollution. Hence, we formulate the following research question: how much will the WSU students willingly accept and/or pay for carpooling? The goal of this paper is to test whether, as a price that carpooling participants will get paid by WSU goes up, the participants will be more willing to participate in a carpooling system. To verify this hypothesis, we arranged a sampling survey at WSU and used contingent valuation method (CVM) to find out the value of carpooling.

## Background

One effective effort to reduce greenhouse gases, carpooling, also known as car-sharing or ride-sharing, has been used by both the private and public sectors. A carpooler, as defined in this paper, is anyone who shares car journeys with one or more other persons in one private vehicle. According to Kendall's studies (1975), the maximum potential benefits of carpooling include up to 10% savings in auto fuel consumption. In addition, we could expect a decrease in the usage of privately owned cars from the increase in average auto occupancy for work-trip

per auto from 1.2 passengers to 2.5, which is average carpool occupancy.

### *Literature Review*

Whether there is a disparity between WTP and WTA has been controversial in literature. Tversky and Kahneman (1991) emphasized the effects of loss aversion, which means “The pain of a given loss is greater than the pleasure of an equivalent gain” (page 1047). The difference in psychological perception causes the disparity of WTP and WTA, but Mansfield (1999) set up a new bit function with modified procedures, which controlled some factors interrupting a true measurement in WTP and WTA, to demonstrate weak support for loss aversion. Moreover, Hanemann (1994) noted that the values of WTP and WTA could be closer to one another when it comes to consideration of public goods, not priced private goods as in ordinary markets. Hanemann found that comparison between the two welfares of WTP and WTA of public goods is more likely to be subject to the substitution effect rather than an income effect because, naturally, public or environmental goods are an imperfect substitute. In other words, an unpleasant change of environmental quality results in an infinitely large difference of welfare compared with the other situation in a private good market where individuals give up some pleasure and the quantity of a good for other pleasures or goods.

### *Theoretical Assumption on WTP/WTA*

Figure 1 shows the different indifference curves for an individual. In this figure,  $U_1$  represents the highest level of utility. This figure also shows the budget constraint of the individual. The budget constraint is flat because  $Y$ , which represents environmental quality, is free for all quantities,  $P(y)=0$ . The budget constraint is given by  $Y \geq P(x) \cdot x_0 + P(y) \cdot y_0$ , where  $Y$  is income,  $P(x)$  and  $P(y)$  are prices, and  $x_0$  and  $y_0$  are the number of units of the goods purchased. The slope of budget line is given by  $-\frac{dy}{dx} = \frac{P(y)}{P(x)}$ . Because the numerator  $P(y)$  would be zero, the value of the fraction equals zero. Thus, the budget line is horizontal and located at  $Y=x_0$ . On this budget line, individual's utility depends only on environmental quality. The more the improved environmental quality, the further to the right on the budget line the individual will be (Folmer & Gabel, 2000).

Let's assume one situation that I am going to ask subjects to answer through the survey later in this paper. This assumption starts with the individual at point A. Since the environmental quality has im-

proved, he moves to point B. However, he will move to point C in order to remain his initial utility since both of point A and C are on the same indifferent curve,  $U_0$ . Hence we can measure how much the im-

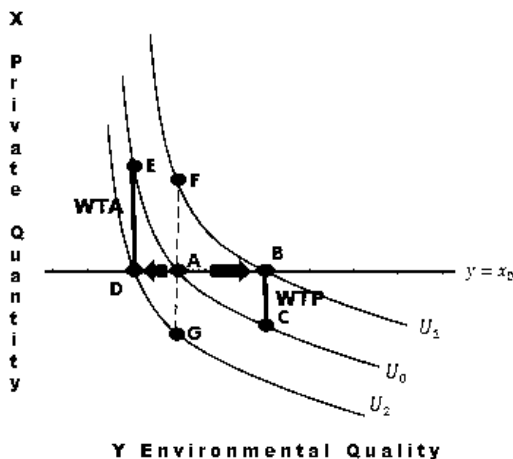


Figure 1. Graphic demonstration of WTP/WTA.

provement of environmental quality is valued by measuring the distance between point B and C. In other words, we can express the WTP of a person with a measure of income. On the other hand, let's assume point A moves to point D. Similarly, in order to stay at the same level of initial utility, a person will move his position from D to E. However, the willingness to pay of this shift would be negative. In fact, this shift from D to E would be achieved by paying the person who willingly accepts the deterioration of environment. In this case, it is needed to compensate the individual's utility at least not to change at the initial level of utility even if the quality of environment decreased from A to D. Calculating the vertical line between D and E would show the amount of compensation.

## Methods

For a measurement of the WTA, the WTA question of Lindhjem and Mitani (2012), Galarraga et al. (2010), and Moon et al. (2004) specifies its manipulated situation with each specific compensating price and with the clearness in unit brought about with the changed utility from simulated assumption. Kennedy (2001) and BW Research Partnership (2007) additionally regarded an individual's level of environmental recognition as a significant independent variable when valu-

ing reservation price. Also, general commuting habits in Toth's (2012) and Ciari's (2012) carpooling survey questionnaires and demographic descriptions in Chilton et al. (2011) were also fulfilled in a survey.

### *Empirical Model and Analysis*

To test my hypothesis, a binary logistic regression model was used. The main interest of this paper is to analyze a correlation between people's willingness to participate in a carpooling system at different prices. However, as explained above, 25 other variables were also measured as followed:

$$Y_i = \beta_0 + \beta_1 X_{\text{Price}} + \beta_2 X_{\text{Recycling}} + \beta_3 X_{\text{PublicTransportation}} + \beta_4 X_{\text{AirQuality}} + \dots + \beta_n X_n$$

where  $Y_i = 1$  when the  $i$ -th person would say "yes" to participate in carpooling and  $Y_i = 0$  if they would not.

The sample of WSU students was taken in a period of November 5–20, 2013, in public places or general classes. A total of 181 WSU students participated in survey, including undergraduates and graduates.

## **Results**

Since a main predictor of interest in this study is price, surveys were administered with 5 different prices (\$0, \$10, \$25, \$50, \$75, and \$250) while all other aspects of the survey were held constant in all surveys as shown in Table 1.

<b>Table 1. Distribution of the respondent and response</b>			
Price (\$)	Yes (%)	No (%)	Total
0	13 (65)	7 (35)	20
10	21 (58)	15 (42)	36
25	17 (49)	18 (51)	35
50	22 (61)	14 (39)	36
75	22 (61)	14 (39)	36
250	13 (72)	5 (28)	18
Total	108 (60)	73 (40)	181

With the results from the first binary logistic regression with 25 variables (Table 2, columns for Equation 1), we could test the hypothesis that paying people to carpool will increase the number of carpoolers. With the positive coefficient on price of 0.0052, the relationship between the direction of the variable price and dependent variable  $Y_i$  is positively correlated. In other words, as price goes up the willingness to

accept carpooling also goes up. With the p-value of the predictor price, 0.07, we can reject the null hypothesis at the highest confidence level of 92.3% in a two-tailed test while at the highest confidence level of 96.15% in a one-tailed test.

Table 2. Logistic Regression Table					
Equation 1 <sup>1</sup>			Equation 2 <sup>2</sup>		
Variable	Estimated Coefficient	P-value	Marginal Effect (%)	Estimated Coefficient	P-value
Intercept	-1.82	0.25		-1.43	0.14
Price (\$)	0.0052	0.07	0.13	0.0041	0.09
Recycling	0.3325	0.17	8.094	0.4008	0.04
Public Transportation	0.0336	0.89	0.818		
Air Quality	-0.018	0.95	-0.43		
Traffic Congestion	0.5975	0.04	14.54	0.6792	0.00
Parking Lot	-0.187	0.43	-4.57	-0.2942	0.18
Driving Alone	-1.053	0.07	-25.6	-0.9926	0.00
Carpooling	1.4390	0.02	35.03		
Bus	-0.964	0.10	-23.4		
Frontrunner	1.7505	0.13	42.61		
Bike	0.1078	0.93	2.625		
Walk	0.6496	0.25	15.81		
Motorcycle	-21.34	0.99	-519.5		
Other	-1.696	0.32	-41.4		
Miles to School	0.0282	0.86	0.688		
Miles to Work	0.0271	0.84	0.660		
Home-type	0.0491	0.87	1.196		
Kids	-0.190	0.30	-4.64		
Year of School	-0.240	0.20	-5.85	-0.1519	0.30
Work-status	0.0231	0.94	0.564		
Age	0.0245	0.57	0.598		
Gender	-0.558	0.11	-13.5	0.5972	0.07
Marriage	0.7518	0.13	18.30		
Ethnicity	-0.066	0.58	-1.60		
Income (\$)	0.1089	0.37	2.652		
<div>* (Note: According to the equation for marginal effect, <math>R_i = (1 - P_i) \times \beta_i = \frac{\partial Y_i}{\partial X_i}</math>; <math>P_i</math> means the probability to say "yes" to a carpooling suggestion.</div> <div><sup>1</sup>Equation 1 <math>Y_i = \beta_0 + \beta_1 X_{Price} + \beta_2 X_{Recycling} + \beta_3 X_{PublicTransportation} + \beta_4 X_{AirQuality} + \dots + \beta_{28} X_{Income}</math></div> <div><sup>2</sup>Equation 2 <math>Y_i = \beta_0 + \beta_1 X_{Price} + \beta_2 X_{Recycling} + \beta_3 X_{TrafficCongestion} + \beta_4 X_{ParkingLot} + \beta_5 X_{DrivingAlone} + \beta_6 X_{YearOfSchool} + \beta_7 X_{Gender}</math></div>					

However, some variables on the regression with a z-score of less than 1.0 in absolute value do not have a strong correlation with dependent variable,  $Y_i$ , which may cause statistical interpretation issues. After eliminating 18 variables with relatively small z-value, we proceed the second regression and the result is shown in Table 2 (columns for Equation 2).

From the second regression, we find that the p-value of a main predictor, price, increases from 0.07 to 0.09, while the p-values of the rest of the independent variables decrease. Using the second equation with only 7 variables, we can deduce the number of estimated students who would participate in a car-sharing system. Using WSU’s total headcount of students (Kowaleski, 2012), the estimate of the number of WSU students who are willing to participate in a car-sharing system at various price points is shown in Figure 2.

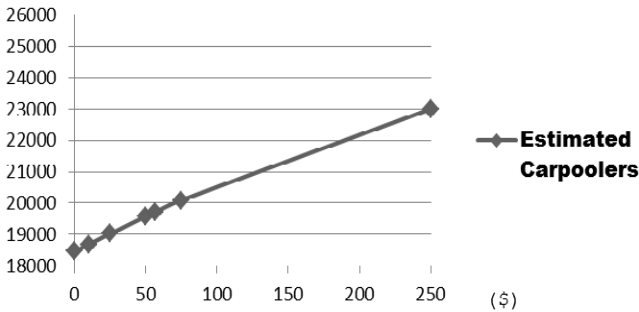


Figure 2. Estimated number of carpoolers at various WTA

## Discussion

This study measured the WTA for carpooling at WSU by using a binary logistic model. The marginal effect of a main predictor, price, indicates that if there is an increase in price by \$1, people are more willing to accept for carpooling by 0.13%. After the elimination of 18 less-correlated variables, we can assume that at the price of zero to compensate students, over 70% of WSU students (18,460) would be already willing to participate in a car-sharing program and at the average price asked for survey candidates for this paper, which is \$56.55, about 73% of the students (19,718) are willing to accept the car-sharing system.

As one way to improve this research in the future, potential researchers may increase the sample size and evaluate a pilot program to pay students to carpool. The current sample represents only 0.67% of the WSU population. Because of the sensitiveness of z-value depending on a sample size, an extended work with a large number of samples may improve the results of the current study.

Moreover, using hypothetical questions on WTA may generate unreliable responses, but results still suggest organizing carpooling at WSU may be both inexpensive and effective. Regardless of the exact level of precision of my estimates, it is important to note that no matter what method was used, a culture of carpooling has not been popular in the Western area of the United States historically. Cities of the western U.S., such as Los Angeles, have mostly grown after World War II. Compared with the rest of the U.S., the East Coast areas such as Boston or New York City had already experienced a big portion of growth in transportation before the war. The less densely populated Western area's transportation system has not grown as much as those in the Eastern U.S. have. Thus, instead of attributing issues to the CVM

analysis, future investigation may improve a carpooling study by carrying on more research in the area with mass transit, especially in the East coast area.

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# Adjunct Faculty Attitudes of Diversity

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## **Abstract**

*Diversity has been an important topic in higher education for many years. Administrators, faculty, and students within higher education have all been able to voice their opinions regarding diversity; however, to our knowledge, this was the first study to focus specifically on the opinions of adjunct faculty. The purpose of this study was to discover the attitudes of adjunct faculty about diversity at Weber State University (WSU). It also sought to understand whether diverse experience had an impact on attitudes toward diversity, as well as to compare relationships between student and adjunct faculty attitudes about diversity on the same campus. We found that the adjunct faculty sample lacked experience with, but not openness to, diversity. The sample perceived that WSU provides resources for diverse opportunities even though they had less diverse experience after coming to the university. Minority groups from the sample were no more likely to incorporate diversity into their curriculum than non-minority groups, and religion had no impact on experience with or openness to diversity. We found that adjunct faculty perceived there were more opportunities that are*

*diverse for students than for themselves and they were unlikely to incorporate diversity into their curriculum. Lastly, outlined in this study are recommendations for improving the campus diversity climate and suggestions for future studies.*

An educational environment that is open to all types of diversity is important to everyone, not only to ensure against discrimination and marginalization, but also to provide the most enriching education for everyone involved. In conjunction with the Weber State University (WSU) Center for Diversity and Unity, we sought to examine the diversity climate on our campus among adjunct faculty. To our knowledge, this was the first study to focus specifically on adjunct faculty, as it is a considerably underrepresented population. Some studies point to an inconsistent definition of diversity as a roadblock to greater incorporation of diverse topics into course work (Hon et al. 1999). Understanding adjunct professor's attitudes about and commitment to teaching diversity may be another step toward improving (Smolen et al. 2006). The amount of diversity-related materials incorporated by adjunct professors into their course work may be an indicator of openness to and attitudes about diversity (Mayhew and Grunwald 2006). Comparison of student and adjunct faculty attitudes toward diversity at WSU could provide great insight into the overall diversity climate (Bonney et al. 2013). The purpose of this study was to discover the attitudes of adjunct faculty about diversity at WSU. It also sought to understand whether diverse experience had an impact on attitudes toward diversity as well as to compare relationships between student and adjunct faculty attitudes about diversity on the same campus.

Queensborough Community College said this about diversity (<http://www.qcc.cuny.edu/diversity/definition.html>):

The concept of diversity encompasses acceptance and respect. It means understanding that each individual is unique, and recognizing our individual differences. These can be along the dimensions of race, ethnicity, gender, sexual orientation, socio-economic status, age, physical abilities, religious beliefs, political beliefs, or other ideologies. It is the exploration of these differences in a safe, positive, and nurturing environment. It is about understanding each other and moving beyond simple tolerance to embracing and celebrating the rich dimensions of diversity contained within each individual. (para. 1)

We used this definition of diversity for our research.

## **Method**

### *Literature Review*

To understand attitudes of diversity among university adjunct professors, it was important to consider previous research on comparable topics. Our literature review considered three studies in an attempt to gain a better understanding of how professors define diversity and about faculty's perceptions, beliefs, and commitment to teaching diversity. In addition, we explored factors that cause faculty to incorporate diversity into their course work. Finally, we considered one study conducted on students at WSU to explore possible correlations between student and adjunct professor attitudes toward diversity.

### **Defining diversity among the professorate**

In an attempt to answer the following two questions, Hon et al. (1999) conducted a study: what does diversity mean to faculty and how they could open diversity as a topic for discussion that was empowering to everyone. Those questions gave them a purpose for their study, which was to define diversity and promote an open dialogue about diversity issues. By far, the most important findings of the Hon et al. (1999) study concerned the faculty's preferred definition of diversity. Responses suggested that faculty had different opinions about what made up a diverse faculty on top of the traditional race, ethnicity, and gender criteria. Faculty believed in considering the following characteristics when hiring to ensure diversity: specific ethnic and racial groups, gender, type of degree, institution of last degree earned, area of scholarship, research method used, years and type of professional experience, sexual preference, disabled status, political ideology, age, region of origin, and religious preference. These findings were important to our study as they raised our awareness about the need for a comprehensive, universal definition of diversity, in addition to providing valuable comparison criteria.

### **Faculty perceptions and commitment to teaching diversity**

The purpose of a study conducted by Smolen et al. (2006) on faculty at College of Education (COE) schools was to answer the question: what are the diverse characteristics, perceptions, beliefs, and commitment to diversity of COE faculty in teacher education programs in four urban institutions with stated multicultural agendas? Their findings uncovered a correlation between where faculty attended college and their perception of diversity. The amount of time faculty spent traveling

outside the U.S. influenced how much they incorporate diversity issues in their courses, how comfortably they talk about diversity, and how sensitive they are to racial differences. Faculty members' racial/ethnic self-identification also influenced their perceptions of multicultural education. This included to what extent they incorporate diversity into their course work and their perceptions of racial sensitivity. The findings of this study created the perception that faculty with more diverse backgrounds would have added openness to diversity and be more likely to incorporate diversity into their curriculum.

### **Incorporation of diversity-related course content**

Mayhew and Grunwald (2006) conducted a survey with the purpose of identifying factors that affect faculty decisions to incorporate diversity-related content into their curriculum. One finding was that faculty members of color were much more likely to incorporate diversity-related content into their course materials. Most importantly, however, a faculty member's personal participation in culturally sensitive events and activities was the strongest indication of their likelihood to incorporate diversity-related content into their course materials. Like the Smolen et al. (2006) study, this study expanded our perception that minority groups would be open to diversity and likely to voluntarily incorporate diversity-related content into their curriculum.

### **Weber State University students**

A study conducted on students at WSU by Bonney et al. (2013) sought to gauge student openness to diversity and diverse interactions. The overall findings of their study showed well-defined openness to diversity in the student body. They also found that people who grew up in Utah had less experience with diversity. Lastly, students who reported a religious affiliation with the Church of Jesus Christ of Latter-Day Saints (LDS) had much less experience with diversity, but they reported being open to it. These findings were important to our study as they provided valuable comparison criteria between students and adjunct faculty on the same campus. Furthermore, the Bonney et al. (2013) study used an openness/experience scale and a definition of diversity that were an excellent fit for our study as they increased comparison validity.

### *Hypotheses*

1. Adjunct professors are open to diversity.
2. Adjunct professors have experience with diversity.

3. Adjunct professors feel WSU is providing resources for diverse opportunities.
4. Adjunct professors have less experience with diversity since coming to WSU.
5. Members of minority groups are more likely to promote diverse activities.
6. There will be a difference in experience with diversity based on religion.
7. There will be a difference in openness to diversity based on religion.

### *Variables*

Previous research showed that experience with diversity had an effect on openness to it. Therefore, we chose experience with diversity prior to coming to WSU as an independent variable. Other independent variables included demographic categories such as race, ethnicity, gender, and religion. Dependent variables included experience with diversity after coming to WSU and openness to diversity in general. We chose those variables partly because of our work with WSU's Center for Diversity and Unity and in support of the Diversity Initiative from that office (Weber State University, 2014). In addition, we believed that adjunct professors' openness to and incorporation of diverse topics in their course work could be a measure of the general attitude about diversity at WSU and a measurement of support for the diversity requirement implemented at the university.

### *Sample*

Our non-probability sample included the 662 adjunct professors in eight colleges at WSU. In conjunction with the Center for Diversity and Unity at WSU, we sent the instrument electronically to the sampling frame through university e-mail. The Center for Diversity and Unity provided six \$25 gift cards to the WSU bookstore as incentive for adjunct professors to respond. Each respondent had an equal chance of receiving a gift card.

We chose to use a cross-sectional study design for available adjunct professors to answer. A design of this type had some strengths and weaknesses worth discussing. A non-probability, availability sample was convenient and less expensive, which was desirable for the research we were doing; however, availability sampling could have been highly susceptible to sampling bias. A cross-sectional study design was desirable since we were seeking to derive causal inferences from our research. Nevertheless, a cross-sectional design only allowed

us to look at one point in time and not to compare how attitudes changed over time. In addition, the motivation of receiving a gift card and not providing thoughtful responses may have produced bias in the study.

## *Measurement*

To measure our variables, we chose to use a modified version of the College Student Experiences Questionnaire (CSEQ) used by Gonyea et al. (2003). The CSEQ has proven reliable over time and through replication. For our purposes, we modified the questions and directed them toward adjunct faculty instead of students. We also chose the CSEQ because of previous research at WSU conducted by Bonney et al. (2013). We felt that using the same instrument would increase the validity of comparison between the two studies. In addition to the CSEQ, we chose to modify and use survey questions from the Association of Independent Colleges and Universities of Pennsylvania (AICUP) campus diversity survey instrument (Marywood University, 2014). We chose to use the AICUP survey because of its face validity and its incorporation of specific ethnic and racial categories to build a comprehensive picture of diversity (Hon et al., 1999). Also included in our survey instrument were standard demographic questions. We used SPSS for Windows to perform descriptive and inferential analysis.

## **Response**

Of the 662 surveys sent out, 141 returned for a gross response rate of 21.3%. After cleaning the 14 blank and 13 unusable, partial surveys, 114 surveys were useable for a net response rate of 17.2%. Of the respondents, 45 (39.5%) were male and 69 (60.5%) were female. Of the race categories, an overwhelming majority of respondents, 102 (89.5%), were white. Since there were so few respondents who identified as a race other than white, we collapsed the remaining race categories into “other,” with which 12 (10.5%) respondents identified. From the sexual orientation category, 109 (95.6%) of the respondents were heterosexual and 5 (4.4%) identified as gay/lesbian/ bisexual/queer. An overwhelming number of respondents belonged to the LDS religion. Therefore, as with the race category, we collapsed religion into three categories: LDS, “none,” and “other,” which accounted for 62 (60.2%), 12 (11.7%), and 29 (28.2%) respondents, respectively. Eleven peoples chose not to respond to this question. Six (5.3%) persons with a disability responded, and 108 (94.7%) reported having no disability. Of the 115 respondents, 13 (11.4%) were single, 90 (78.9%) were married, 10 (8.8%) divorced, and 1 (0.9%) was widowed. When asked whether

they had lived in Utah their entire life, 89 (78.1%) responded negatively while 25 (21.9%) had only lived in Utah. Concerning the type of household they came from, 95 (83.3%) respondents reported being raised in a traditional household while 19 (16.7%) came from non-traditional families. A second language was spoken by 44 (38.9%) respondents, while 69 (61.1%) did not speak a second language, and one respondent left this question blank.

Interestingly, the College of Arts and Humanities had the highest number of respondents with 32 (28.1%) and the College of Business had the lowest number with 3 (2.6%). Responses from the remaining colleges were Social and Behavioral Sciences 19 (16.7%), Education 17 (14.9%), Science 13 (11.4%), Health Professions 13 (11.4%), College of Applied Science and Technologies 11 (9.6%), and Non-Affiliated 6 (5.3%). The majority of respondents, 50 (44.2%), taught general education courses; 32 (28.3%) taught classes as part of a major requirement, 19 (16.8%) taught electives, 12 (10.6%) reported teaching "other" classes, and one respondent left this question blank. The respondents reported their highest level of education as 69 (61.1%) Masters, 23 (20.4%) PhDs, 21 (18.6%) Bachelors, and one respondent left this question blank.

## Results

For our first hypothesis that adjunct professors are open to diversity, we chose to compare the mean response of 23.57 with a neutral response of 21.00 as we felt that was a valid indicator of overall openness. There was a statistically significant difference between our response and a neutral response ( $t(114) = 8.19, p = 0.00$ ), which confirmed hypothesis 1. However, we should mention that our mean response of 23.57, while indicative of a response that was more positive than neutral, was less than a positive response of 28.00.

We also chose to compare the mean result of 18.36 from our second hypothesis that adjunct professors would have experience with diversity with a neutral response of 17.50 to indicate overall experience with diversity. There was not a statistically significant difference between our mean result and a neutral response ( $t(114) = 1.84, p = 0.06$ ). Consequently, we could not confirm hypothesis 2.

Relating to hypothesis 3, Table 1 includes a cross tabulation between the questions, "WSU provides diverse opportunities for students" and "WSU provides diverse opportunities for adjunct faculty."

There was statistically significant difference (Kendall's Tau  $B = 0.58, p = 0.00$ ), indicating overall concurrence with the two statements, which confirmed hypothesis 3.

<b>Table 1. Number of respondents answering questions about hypothesis 3, which asked whether WSU is providing diverse opportunities</b>					
<b>For students</b>	<b>For adjunct faculty</b>				
	<b>strongly disagree</b>	<b>disagree</b>	<b>agree</b>	<b>strongly agree</b>	<b>total</b>
<b>Strongly disagree</b>	1	0	0	0	1
<b>Disagree</b>	2	3	0	0	5
<b>Agree</b>	1	19	50	1	71
<b>Strongly agree</b>	0	3	15	20	38
<b>Total</b>	4	25	65	21	115

We confirmed our fourth hypothesis that stated adjunct professors would have less experience with diversity since coming to WSU. To measure this, we asked two questions about contact with 13 different demographic categories from the AICUP survey. One question asked about how much contact respondents had with each group prior to coming to WSU. The other question asked about how much contact respondents had with each group while at WSU. Table 2 shows a comparison of the two responses in a paired samples test. We collapsed all groups to get an overall comparison and found ( $t(114) = -4.12, p = 0.00$ ) a statistically significant difference that indicated less experience. We also compared the groups individually and found a statistically significant difference for 6 of the 13 groups indicating less experience with these groups in particular. They were African Americans ( $t(114) = -5.13, p = 0.00$ ), Asians/Pacific Islanders ( $t(114) = -3.82, p = 0.00$ ), Chicanos/Latinos/Hispanics ( $t(114) = -3.872, p = 0.00$ ), openly Gay/Lesbian/Bisexual ( $t(114) = -2.28, p = 0.02$ ), Intersex/Transgender ( $t(114) = -2.35, p = 0.02$ ), and persons with a disability ( $t(114) = -3.92, p = 0.00$ ). Categories that showed no statistically significant difference between experience prior to and after coming to WSU were American Indians ( $t(114) = -1.74, p = 0.08$ ), Whites/Caucasians ( $t(114) = -0.62, p = 0.53$ ), Non-Native English Speaking ( $t(114) = -1.63, p = 0.10$ ), persons from different economic backgrounds ( $t(114) = -0.55, p = 0.58$ ), persons with different religious backgrounds ( $t(114) = -1.45, p = 0.14$ ), persons from other countries ( $t(114) = -1.36, p = 0.17$ ), and persons with different political views ( $t(114) = -1.68, p = 0.09$ ).

**Table 2. Adjunct faculty self-evaluation of contact with individuals in various demographic categories while at WSU vs. prior contact**

Demographic groups	t	Sig. (2-tailed)
Overall	-4.12	0.00*
African Americans	-5.13	0.00*
American Indians	-1.74	0.08
Asians/Pacific Islanders	-3.82	0.00*
Chicanos/Latinos/Hispanics	-3.87	0.00*
Whites/Caucasians	-0.62	0.53
Non Native English speaking	-1.63	0.10
Openly Gay, Lesbian, Bisexual	-2.28	0.02*
Intersex/Transgendered	-2.35	0.02*
Different economic backgrounds	-0.55	0.58
Different religious backgrounds	-1.45	0.14
Persons with a disability	-3.92	0.00*
Persons from other countries	-1.36	0.17
Different political views	-1.68	0.09

\*A Sig. value of less than .05 indicates statistical significance.

Regarding hypothesis five, we ran statistical analysis of responses from non-whites, women, and religions other than LDS, as well as responses that indicated speaking a second language. We were unable to find statistically significant differences indicating that minority groups would be more likely to promote diverse activities. Furthermore, we discovered that adjunct faculty were unlikely to promote diverse activities overall. We determined this by combining the four survey questions about promoting attendance at diverse activities and cultural events. In a one sample T-test, we compared the mean adjunct professor response of 9.43 to a neutral response of 10.00. There was no statistically significant difference to indicate promotion of attendance at diverse activities or cultural events ( $t(114) = -1.77, p = 0.07$ ). Consequently, we were unable to confirm hypothesis five.

We were also unable to confirm hypotheses six or seven. After collapsing all the religion categories into LDS, "none," and "other," we ran an analysis of variance (ANOVA) between groups regarding religion and experience or openness to diversity. There was not a statistically significant difference between a neutral response, and the mean square regarding openness to diversity shown by ( $F(2, 100) = 2.56, p = 0.08$ ). Finally, there was not a statistically significant difference between a neutral response and the mean square regarding experience with diversity shown by ( $F(2, 100) = 0.47, p = 0.62$ ).

## Discussion

Many of our hypotheses were based on findings from the Bonney et al. (2013) study conducted on the WSU student body. We hypothesized that adjunct faculty, like the student body, would be open to diversity, and that was indeed what we found at WSU. In contrast, we expected adjunct faculty, unlike the student body, to be from places other than Utah and therefore have more experience with diversity. We were mistaken in that expectation. Our question about experience with diversity was based on the Hon et al. (1999) study. We divided our question about experience with diversity into several specific racial/ethnic categories to facilitate a comprehensive definition of diversity. The hypothesis that adjunct faculty would be from places other than Utah led us to believe that they would have less experience with diversity since coming to WSU, which aligns with the findings of the Smolen et al. (2006) and Bonney et al. (2013) studies. That hypothesis was correct overall but varied depending on the specific aspect of diversity measured. We thought that the Bonney et al. (2013) study's findings of overall openness to diversity at WSU could be an indicator that there were resources for diverse opportunities on campus, and that was exactly the case. The Smolen et al. (1999) and Mayhew and Grunwald (2006) studies indicated to us that persons of minority groups might be more likely to promote attendance at culturally diverse events outside of class. WSU does not follow those indications, possibly because of the lack of adjunct faculty who fall into a minority category. Finally, considering the substantial correlation between religion and openness to and experience with diversity seen in the Bonney et al. (2013) study of the student body, we expected to find the same concerning adjunct professors, which did not turn out to be the case.

Some important limitations need discussion. One is our study's time constraints. Our survey was only available for three weeks. While three weeks was a substantial amount of time, it was partially during spring break when the possibility of adjunct faculty being away from their university e-mail accounts could have been high. Another is non-response bias due to our overall response rate of 21.3% with only a 17.4% net useable response rate. Non-response bias was considered but not resolved. In addition to timing limitations and non-response bias are the inherent shortcomings of a cross-sectional study design. As previously mentioned, it does not allow us to determine how attitudes about diversity might change over time. Lastly, the use of a non-probability sample could be a limitation because the useable response rate of 17.4% cannot be readily generalized to represent the entire adjunct faculty population.

## Conclusion

It was reassuring to discover that adjunct professors felt WSU was providing diverse opportunities for students, even though they were less optimistic about those same opportunities for themselves. It was discouraging, however, to discover that adjunct faculty did not promote attendance at out-of-class diversity-related events and activities. Unfortunately, we overlooked the potential importance of a Mayhew and Grunwald (2006) finding, which isolated faculty attendance at diverse activities as the biggest indicator of their likelihood to incorporate diversity-related content into their curriculum. Adjunct professors may have felt excluded from invitation to on-campus, diversity-related events and activities. One recommendation was for the Center for Diversity and Unity to target adjunct faculty specifically when they promote on-campus, diversity-focused events. An additional recommendation was for WSU and the Center for Diversity and Unity to consider changing the diversity requirement for all undergraduate students. At the time of this study, undergraduate students were not required to take any classes that specifically focused on issues in diversity. Future studies may want to investigate faculty perceptions of inclusivity in campus event invitations as an indicator of attendance at those events, with follow-up to see how many adjunct professors actually attend diversity-focused events. Other studies could consider the proportion of adjunct faculty who teach online classes and measure whether that has any impact on diverse interactions with students. Finally, in an effort to understand the diversity climate on campus completely, it may be valuable to consider the perceptions of non-teaching, university staff in regards to diversity.

## Acknowledgments

This research was supported in part by the Office of Diversity and Unity at Weber State University.

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# Effects of Religious Fundamentalism on Sex-Related Attitudes about the Self and Others

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## **Abstract**

*Research has established relationships between religious fundamentalism, sexual guilt, and attitudes towards gays, lesbians, pornography and mechanical devices and other paraphernalia used for sex. The current study examined the mediating role of sexual guilt between religiosity and attitudes towards gays and lesbians, as well as the use of pornography and mechanical devices used for sex. A survey was distributed to a sample of N=349 college students at a small university in the southwestern region of the United States. We predicted that sexual guilt would serve as a mediator between religious fundamentalism and attitudes towards gays and lesbians, as well as mechanical devices used for sex and pornography use. Results indicated that religiosity was a key predictor in attitudes towards homosexuals and sex guilt and that guilt about sex mediated attitudes about homosexuality and use of sex paraphernalia. Limitations to this study include our sample having limited variability across ethnicity, religion, and age. Future studies*

*should include studies with more ethnic and religious diversity and research focusing on clinical therapy for sexual guilt and discrimination. The current study helps to illustrate how sexual guilt derives from religious fundamentalism, which in turn affects individuals' attitudes about sexual practices for themselves and others.*

Religious fundamentalism is the belief that there is one set of basic and absolute truths about deity and humankind and that there is evil opposition at play to fight those basic beliefs and truths (Altemeyer and Hunsberger, 2004). This mindset can cause individuals who strongly associate with particular religions to show an aversion to those who act in opposition to their beliefs and practices (Altemeyer and Hunsberger, 2004). According to Altemeyer and Hunsberger (2004), religious fundamentalism can be manifested in various ways, which include belief in a traditional God, frequently attending church, a tendency towards authoritarianism, and hostility towards lesbian women and gay men.

Research has suggested relationships between religious fundamentalism and sexual guilt, which in turn has been predicted to lead towards prejudice against individuals who live contrary to their moral beliefs. Sexual guilt is classified as self-induced punishment individuals place upon behaviors and attitudes that violate moral standards in relation to religious fundamentalism (Gravel et al. 2011). The aim of this study is to investigate the mediating role of sexual guilt on religious fundamentalism and how it affects an individual's attitudes towards lesbian women and gay men, the use of pornography, and the use of sex paraphernalia.

Religious fundamentalism is also considered to be motivated by both intrinsic and extrinsic gain (Albertsen et al. 2006). Intrinsic gain refers to following religious beliefs and morals because it gives individuals a sense of self-motivation and their own mystical experiences, whereas extrinsic gain causes individuals to be motivated by what others tell them is morally right. Guilt is an emotion that motivates individuals to live by their moral standards and religious beliefs (Albertsen et al. 2006). The level of guilt felt by religious fundamentalism is dependent upon whether a person is motivated intrinsically or extrinsically (Albertsen et al. 2006). Further, there is a difference in level of guilt between individuals who claim to be religious versus those who just consider themselves spiritual. Research has shown that religious individuals reported higher guilt than those who were spiritual, and individuals who claimed no religion reported the smallest amount of interpersonal guilt (Albertsen et al., 2006).

Religious fundamentalism has also been shown to affect attitudes towards alternative lifestyles, especially individuals who are lesbian or gay. Although religious teachings stress the importance of unconditional love and acceptance, many religious individuals hold prejudices and discriminate against alternative lifestyles (Scourfield et al. 2008). Religion was a key predictor of possible prejudice towards lesbians and gays, and homosexuals were stereotyped as breaking traditional gender roles within traditional heterosexual relationships (Cunningham and Melton 2013). Cunningham and Melton (2013) and Whitley (2009) also found that religious fundamentalists were more likely to express sexual prejudices against gays and lesbians.

Religious fundamentalism has also been linked to attitudes about sex-related media, such as pornography and sex paraphernalia (e.g., vibrator) use (Stack 2004). The use of pornography has shown weak ties to religiousness in that the more religious an individual, the more aversive they will be to sex-related media and the more they condemn sexual deviance (Stack, 2004). Incidentally, research also suggests that sexual deviance away from the prescribed religiously appropriate activities is related to the amount of surveillance that organized churches impose on followers (Stack, 2004).

Research has also suggested a relationship between sexual guilt and the use of sex-related paraphernalia. According to Gravel et al. (2011), sexuality is influenced through culture, and normative sexual behavior does differ across cultures. Gilliland et al. (2011) found a significant relationship between religious fundamentalism and shame or guilt caused by hypersexual behavior, especially in the case of pornography addicts. According to this research, the intensity of shame an individual felt because they engaged in hypersexual behavior affected the intensity with which they continued to engage in the behavior of viewing pornography and using sex-related media (Gilliland et al. 2011). Sexual guilt was also shown to limit the amount of hypersexual behavior (i.e., intense sexual urges) a person engaged in, while shame had a positive correlation with maladaptive hypersexual behavior (Gilliland et al. 2011). In sum, religious fundamentalism does have an effect on sexual guilt and attitudes towards homosexuals, pornography, and sex paraphernalia use.

Based on previous research related to religious fundamentalism, sexuality, sexual guilt, and attitudes towards homosexuals and sex-related media, we hypothesize that sex-related guilt will mediate the relationship between religious fundamentalism and (a) attitude towards gays; (b) attitude towards lesbians; (c) sex paraphernalia use; and (d) pornographic material use.

## Method

### *Participants and Procedure*

A total of 349 participants completed a paper/pencil survey. The final sample included 339 participants ( $n=196$  women,  $n=143$  men) after the deletion of surveys that were incomplete. Participant ages ranged from 18 to 68 years, with an average age of 26.27 ( $SD=9.78$ ). The sample was primarily Caucasian (56%) with a smaller representation of African Americans (3%), Asian Americans (0.9%), Hispanics (2%), Pacific Islanders (2%), and other (26%). The most common self-reported religious affiliation ( $n=203$ ) was with the Church of Jesus Christ of Latter Day Saints (LDS/Mormon). Refer to Table 1 to view a more complete summary of participant religious preference.

### *Measures*

#### **Demographic characteristics**

Participants provided demographic information, including: gender, age, and religious preference.

#### **Religious fundamentalism**

Participants were asked to answer 12 questions about how religiously fundamental they feel they are (Altemeyer and Hunsberger 2004) (e.g., God has given humanity a complete, unfailing guide to happiness and salvation, which must be totally followed?). Responses ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach's alpha for this scale was  $\alpha=.92$ .

#### **Sexual guilt**

Participants were asked to answer 10 questions about guilt related to sex (Janda and Bazemore 2011) (e.g., When I have sexual dreams, I try to forget them). Responses ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach's alpha for this scale was  $\alpha=.73$ .

#### **Attitudes toward lesbians and gay men**

Participants were asked 10 questions pertaining to their attitudes toward lesbians and 10 pertaining to their attitudes toward gays (Herek 1988) (e.g., Homosexual behavior between two men is just plain wrong). Responses ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach's alpha for attitudes toward lesbians was  $\alpha=.93$ , and the Cronbach's alpha for attitudes toward gays was  $\alpha=.94$ .

<b>Table 1. Summary of Participants Religious Preferences</b>	
<b>Religious Preference</b>	<b>n</b>
None	43
Agnostic	25
Atheist	5
Baptist	6
Buddhist	3
Catholic	18
Hindu	1
Jewish	1
LDS/Mormon (The Church of Jesus Christ of Latter Day Saints)	203
Lutheran	1
Muslim	1
Other (declined to identify specific religious preference)	13
Presbyterian	1
Protestant	4
Non-denominational Christian	8
Greek Orthodox	1
Spiritual, Not Religious	5
Undecided	1

### **Frequency of viewing pornographic material**

Participants were asked how often they view pornographic material. Responses ranged from 1 (*Several times a day*) to 6 (*Never*).

### **Frequency of using sexual paraphernalia during encounters**

Participants were asked how often they used sex toys or other sex devices. Responses ranged from 1 (*Several times a day*) to 6 (*Never*).

### ***Procedure***

Each participant was recruited through advertisements provided by an instructor or research assistant across numerous classes at a state college in the western United States during March–April 2012. Each prospective participant was provided with an informed consent consistent with APA ethical guidelines. Participants completed the survey for this study during class time and were provided with course credit for their participation in the study. If prospective participants were absent from the class the day that the survey was administered in class, they

were informed that they could participate in the study during the principal investigator's office hours.

## Results

Mediation procedures (Baron and Kenny 1986) were utilized to analyze the data. Tables 2 and 3 display the significant relationships between the predictor, mediating, and criterion variables. As a condition of conducting statistical mediation, the predictor variable must be significantly correlated with the mediator variable and each of the criterion variables. As seen in Table 2, religious fundamentalism is significantly correlated with sexual guilt ( $r=.63$ ,  $p<.01$ ), viewing of pornographic material ( $r=.33$ ,  $p<.01$ ), use of sex toys/paraphernalia ( $r=.25$ ,  $p<.01$ ), attitudes toward gays ( $r=.68$ ,  $p<.01$ ), and attitudes toward lesbians ( $r=.70$ ,  $p<.01$ ).

Finally, we examined the combined effects of the predictor and mediator on each of the dependent variables. If a previously significant predictor becomes non-significant in the presence of the mediator, this would suggest that sexual harassment fully mediates the effects of job insecurity on the outcome variables of interest; on the other hand, a reduced (but still significant) relationship indicates a partial mediation model allowing for direct and mediating effects may be more appropriate (Baron and Kenny, 1986). Because the Baron and Kenny approach does not provide a direct statistical significance test of the indirect effect, we utilized the Sobel (1982) test bootstrapping technique developed by Preacher and Hayes (2004) to estimate 95% confidence inter-

**Table 2. Descriptive Characteristics and Pearson Correlation Coefficients of Study Variables**

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6
1. Religious Fundamentalism	3.13	1.00	.92					
2. Sexual Guilt	3.05	0.73	.63**	.73				
3. Look at Pornographic Material	5.39	0.98	.33**	.42**	-			
4. Use of Paraphernalia (toys or other devices) during Sex	5.44	0.92	.25**	.34**	.22**	-		
5. Attitudes Toward Gays	2.89	1.12	.68**	.65**	.22**	.28**	.94	
6. Attitude Toward Lesbians	2.59	1.00	.70**	.70**	.30**	.28**	.89**	.93

\*  $p < 0.05$ , \*\*  $p < 0.01$ , Cronbach's coefficient alpha on the diagonal.

vals for the size of the indirect effects if initial support for partial or full mediating models was found using the Baron and Kenny approach.

Further, the fourth step of the mediation analyses shows a full mediation effect across Hypotheses 1c and 1d; with partial mediation across Hypotheses 1a and 1b. Furthermore, the Sobel test (Preacher and Hayes 2004) provided evidence that the mediations analyses were significant at a 95% confidence interval.

## Discussion

The aim of this study was to examine how religious fundamentalism relates to guilt and attitudes associated with sex and sexuality. Our results support the hypotheses predicting that sex-related guilt will mediate the relationship between religious fundamentalism and (a) attitude towards gays; (b) attitude towards lesbians; (c) sex toy or device use; and, (d) pornographic material use.

## Theoretical Implications

Our results provide evidence that religious fundamentalism is one of the key predictors creating individual guilt about sex (Albertsen et al. 2006). In turn, sexual guilt contributes to negative attitudes about use of pornography, use of sex devices, and negative attitude towards gays and lesbians. Because of moral beliefs and standards, individuals

**Table 3. Mediation Tests of Model I: Sexual Guilt as Mediator**

Predictor	Mediator	Criterion	Predictor → mediator			Mediator → criterion			Predictor → criterion			Predictor + mediator → criterion			
			$\beta$	$R^2$	$F(df)$	$\beta$	$R^2$	$F(df)$	$\beta$	$R^2$	$F(df)$	$\beta_{\text{total}}$	$\beta_{\text{mediator}}$	$R^2$	$F(df)$
Religious Fundamentalism	Sex Guilt	Attitude towards Gays	.63**	.40	226.47** (341)	.65**	.42	253.67** (347)	.68**	.46	292.56** (340)	.45**	.37**	.54	200.00** (340)
Religious Fundamentalism	Sex Guilt	Attitudes towards Lesbians	.63**	.40	226.47** (341)	.70**	.49	335.64** (347)	.70**	.50	332.75** (340)	.43**	.43**	.61	259.57** (340)
Religious Fundamentalism	Sex Guilt	Porn Material Use	.63**	.40	226.47** (341)	.42**	.17	71.65** (341)	.33**	.11	39.545** (334)	.09	.36**	.18	36.85** (334)
Religious Fundamentalism	Sex Guilt	Sex Toy Use	.63**	.40	226.47** (341)	.34**	.12	44.58** (341)	.25**	.06	22.66** (334)	.06	.29**	.11	21.22** (334)
			Mediation Effect (95% CI)												
Predictor	Mediator	Criterion	Effect (SE)												
Religious Fundamentalism	Sex Guilt	Attitudes Toward Gays	.23(.04) Partial (.15→ .31)												
Religious Fundamentalism	Sex Guilt	Attitudes Toward Lesbians	.24(.04) Partial (.17→ .31)												
Religious Fundamentalism	Sex Guilt	Porn Material Use	.12(.05) Full (.10→ .30)												
Religious Fundamentalism	Sex Guilt	Sex Toy Use	.20(.05) Full (.02→ .31)												

$\beta$  = Standardized regression coefficients; Full = Full mediation effect; 95% CI provides 95% confidence intervals for the estimate of the size of the indirect effect using 5000 bootstrap resamples (Preacher and Hayes 2004). Gender, age, and ethnicity were controlled for in the analyses. \*  $p < .05$ ; \*\*  $p < .01$

who are highly religious tend to feel more sexual guilt (Gilliland et al. 2011). Research suggests both that guilt is an unnecessary and destructive result of religion and that interpersonal guilt causes individuals to judge others' behaviors based on beliefs they presume to be morally correct (Albertsen et al. 2006). High religiosity is also associated with overcontrol, which is maladaptive because it causes excessive guilt within religious individuals (Albertsen et al. 2006). This is a substantial factor because it illustrates that sexual guilt related to religious fundamentalism causes individuals to dictate how other people should live based on their own personal beliefs and social expectations.

### *Practical Implications*

This research can also help illustrate the importance of educating people that sex guilt affects individuals' attitudes toward lesbians, gays, sex toys, and porn use, regardless of religious affiliation. Often, religion has been accused of being the determining factor in swaying individuals' attitudes about their own personal sexual activity as well as their attitudes about others' sexual activity; however, the results of our study show that guilt about sex, associated with religious fundamentalism (i.e., religious fundamentalism being a different construct apart from religion), explain attitudes about sex. As such, creating a general awareness about the contribution of guilt about sex upon attitudes of sex may alleviate some of the blame that media places upon organized religion. For example, media reports associate members of particular religions with having negative attitudes about sex and sexuality; however, this study shows that the relationship between religion and attitudes about sex are more nuanced and complicated.

The results of this study can inform clinicians who are treating clients who subscribe to religious fundamentalism and are having issues pertaining to sexual guilt. Although religious fundamentalism in itself is not maladaptive, the guilt that it causes can be maladaptive and promote discrimination against other's who identify as gay or lesbian, which is shown to lead to low-self-esteem, thoughts of suicide, loneliness, and isolation. (Armesto and Weisman 2001). Guilt can also be maladaptive because it inhibits individuals by causing irrational and unrealistic worry, and most times it affects a person's life at an unconscious level (Albertsen et al. 2006). The current study helps to illustrate the need for possible clinical intervention in the form of counseling and therapy to address the effect that sexual guilt has on an individual's well-being, in addition to the discrimination they exhibit towards gays and lesbians.

## *Limitations*

Although this study makes several contributions, it is not without limitations that should be addressed in future studies. The cross-sectional and self-report design, with all variables coming from one single source (i.e., the survey), could pose the problem of common method bias. The use of cross-sectional data in this research presents a limitation as the survey was administered in a manner that takes a snapshot of individual's experiences.

Several limitations related to the demographic characteristics of the sample in our study include the fact that our sample population was not representative of the greater population. The sample included an imbalance of diversity, religion, and age, which may have affected the results. The region in which this survey was conducted has had an effect on the sample population, because the dominant religion of this area is LDS/Mormon. The ethnic diversity in the area is also minimal because the majority of the population is of Caucasian descent. There also could have been a difference in opinions and views regarding homosexuality, sex-toy, and porn use of religious fundamentalists' among an older age demographic.

## *Future Studies*

While the current study provides useful insights about how religious fundamentalism and sexual guilt affect sex-related outcomes, future studies could broaden the knowledge in this area. First, future research could include surveying other areas that have a more diverse religious and ethnic population. By looking at a larger sample of participants that is more diverse in terms of religious affiliation, ethnicity, and age researchers will be able to better determine whether sex guilt serves as a mediator of religious fundamentalism and attitudes towards gays/lesbians, sex paraphernalia use, and pornography use across diverse populations.

Second, future studies could also focus on how clinical therapy may help with sexual guilt and discrimination towards gays and lesbians. By focusing on possible therapy methods, researchers might be able to find ways both to help decrease sexual guilt and to help individuals understand that their own personal beliefs and morals should not be imposed on other individuals. There also may be individual and group therapy methods that could help gays and lesbians cope with physical and psychological distress that religious discrimination causes.

## Conclusion

By conducting this research, we are able to help understand the effect that religious fundamentalism has on an individual's sexual guilt, as well as porn and sex toy use. The results suggested that higher religious fundamentalism affected individual sex guilt, porn use, and sex toy use. The results also showed a full mediation effect that sexual guilt had between religious fundamentalism and porn and sex toy use. There was a partial mediation effect that sex guilt had between religious fundamentalism and attitudes towards lesbians and gays. The purpose of this research was to help bring attention to some of the indicators that affect religious fundamentalism with sexual guilt as a mediator.

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# **Sources of Mormon Religious Activity in the United States: How Latter-day Saint Communities Function where Mormons Predominate and Where They Are Sparse**

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## **Abstract**

*Studies of religious activity in the United States find that rates of church participation within denominations are generally inversely correlated with the percentage of the population in any given geographic unit belonging to that denomination. The exception to this “market share” thesis is the Church of Jesus Christ of Latter-day Saints (the LDS, or Mormon Church). This paper demonstrates how dense Mormon communities in Utah and Southeastern Idaho foster unique cultural dynamics that allow the LDS Church to sustain high religious activity in settings where the church predominates, contrary to the predictions of the market share thesis. Outside of these dense communities, the paper finds that dynamics of Mormon religious activity resemble those in other denominations.*

An extensive research program in the sociology of religion focuses on how levels of religious pluralism affect religious behavior in the United States. One finding from this program is that rates of religious participation among members of a given denomination tend to be lowest in places where that denomination predominates and highest where it comprises a small proportion of the population. This generalization is called the “market share” thesis, and it is based on the logic of economics. According to this thesis, all of the potential church members and all of the churches they may join in a particular, discrete geographic unit constitute a “religious market.” The thesis holds that when a denomination has a small share of a given “religious market,” its members tend to have few neighbors or co-workers who worship with them or share their specific beliefs. Social relationships outside the denomination can facilitate religious switching, so small market share churches must strive to retain their members. The smaller the market share, the stronger the incentive for priests and pastors to serve their flock with diligence, since dissatisfied members have many options if their religious needs are unmet. Hence, a religious market functions like the market for any other good or service. Denominations with an attractive “product” thrive, and those with an unpopular “product” languish. Several sources review and assess the literature on religious markets and the market share thesis (see Stark and Finke 2000:193-217; Chaves and Gorski 2001; Olson 2008).

The market share thesis has broad empirical support in the United States. An inverse correlation between market share and religious activity is observed for Protestants, Catholics, and Jews (Stark and McCann 1993; Rabinowitz et al. 1995; Lopez and Santos 2008; Alper and Olson 2013). The correlation holds for various measures of religious activity. For example, in places where denominations claim a small segment of the population, they tend to exhibit higher rates of church attendance, elicit more extensive financial support, and evince more committed members than in places where they are more abundant (Perl and Olson 2000; Olson and Sikkink 2004; Brewer et al. 2006; Cohen-Zada and Elder 2012; Hoverd et al. 2102).

## **The Mormon Exception**

The exception to this rule is The Church of Jesus Christ of Latter-day Saints (the LDS, or Mormon Church). Available evidence suggests that religious activity within the LDS Church is highest in dense Mormon enclaves in Utah and southeastern Idaho (Mauss 1994; Albrecht 1998). The LDS Church does not generally provide data on its members that are suitable for testing the market share thesis; however, in

1980 the church published membership statistics for Utah's 29 counties, including the percentage of Mormon men in each county that had been ordained to the highest order of Mormonism's lay priesthood (called the Melchizedek priesthood) in each county (*Deseret News 1982 Church Almanac* 1981:220-221). Phillips (1998) used these figures as a measure of religious activity to test the market share thesis and found that the percentage of eligible men who had been ordained to the Melchizedek priesthood in Utah counties rose in concert with the percentage of each county's population belonging to the LDS church. Thus, in Utah, Mormons are most active where they most densely concentrated. This is the only study examining religious activity within a specific denomination that rebuts the market share thesis.

Proponents of the market share thesis do not challenge the veracity of this finding. Instead, they argue that Mormonism in Utah is a special case and constitutes an exception to an otherwise established rule. They assert that Utah's unusual religious demography obstructs the processes that allow religious markets to function (Stark and Finke 2004:294; Olson 2008:102; Alper and Olson 2013:102). According to Kosmin and Lachman (1993:61), "Mormons dominate Utah more than any other denomination dominates a state" and "Mormons are the most geographically isolated and uniquely distributed religious group in the nation" (see also Shortridge 1976; Bennion 1995; Warf and Winsberg 2008.) This isolation and distribution fosters a denominational subculture that is intertwined with the LDS Church, but that also possesses autonomous characteristics extending beyond the formal programs and activities of the institutional church (Meinig 1965; May 1987:196; Embry 2001:4-5, 22; Rogers 2003; Toney, Keller and Hunter 2003). Mechanisms for promoting religious activity in this subculture are different than those found in typical religious markets. Two such mechanisms are the consolidation of kinship and religious networks, and the blending of religious and secular life.

Most Mormons in Utah were born and raised in the faith, and many are direct descendants of the pioneers that settled the region (Heaton 1998:116-117; Pew Research Religion and Public Life Project 2009; Phillips and Cragun 2011). This infuses their genealogy with religious significance. Scholars have argued that Utah Mormons possess many characteristics of an ethnic group (see May 1980; O'Dea 1957). Historian Michael Quinn (1997) describes the twentieth-century Mormon hierarchy as an enormous extended family, pervasively linked by blood and marriage. Ethnographers in the early and middle decades of the twentieth century equated the Mormon lifestyle with conformity to ethnic customs (Bahr 2014:152-182). While the hierarchy has since diversified and the state is now more cosmopolitan, these elements of

Mormon life in Utah are still perceptible, and they bolster religious activity in the region (Phillips 2004).

The sheer density of Mormons in Utah also promotes religious activity. Kelley and De Graaf (1997:639-659) observe that in places where nearly everyone shares the same faith, religious precepts can become axiomatic, because they are not embattled or seriously contested. Pervasive beliefs seem plausible and are easier to adopt and maintain (see Berger 1967). In addition, when nearly everyone shares the same faith, religious and public norms can fuse (Wollschleger and Beach 2013; Sosis 2005). In some Utah communities, social networks at work, at school, and in the neighborhood are all stocked with Latter-day Saints. This allows Mormons to observe one another in non-church settings and makes deviance from church standards subject to wider disapproval. Ethnographic studies of Utah Mormons have found that such deviance can cause problems with coworkers, classmates, and neighbors (Knowlton 1976; Phillips 2001; Marlowe 2005; Cope 2009). The fusion of religious and public norms helps Mormons stay on the straight and narrow when they might otherwise be tempted to stray.

In sum, the Utah way of life is, in many respects, a Mormon way of life—a state of affairs that has vexed some non-Mormons in the state for over a century (Marlowe 2005; Sessions 1996; Barber 1995). Even converts to the church living in places where Mormons are scarce sometimes draw distinctions between themselves and Utah Mormons. They claim that aspects of the Utah Mormon subculture are not necessarily derived from the doctrines and programs of the church (Moloney 1989; Phillips 2001; Horne 2009:43). For these reasons, scholars conclude that the market share thesis does not apply in Utah.

## Sources of Mormon Vitality

Utah is an atypical religious market. Utah Mormons have characteristics distinguishing them from other Christians and also from Mormons who live in places where the LDS Church is a minority faith (Bennion 1995; Phillips and Cragun 2011). Outside the Intermountain West, the typical Mormon is a first-generation convert to the church with few Mormon neighbors or relatives (Heaton 1998:116-117). In 1980, when the data used to establish the Mormon exception to the market share thesis were released, only 37% of U.S. Mormons lived in Utah, and no state east of the Mississippi River was even 1% LDS (*Deseret News* 1982 *Church Almanac* 1981:220-221). Hence, in 1980, most American Mormons lived in typical religious markets. Despite lacking the subculture that bolsters religious activity in Utah, Mormonism in these typical markets was an attractive “product,” as demon-

strated by its expansive growth and high rates of church participation (Gibbons 1999; Koltko-Rivera 2012).

Could the vitality of Mormonism in small market share settings be evidence that the sources of religious activity proposed by the market share thesis function within the LDS Church when it is a small minority faith, but not where it holds a veritable monopoly? Can we find additional evidence to confirm that dense concentrations of Mormons in Utah and adjacent states suppress religious markets and produce qualitatively different sources of religious activity? In the remainder of this paper, I address these questions.

## Data and Hypotheses

The LDS Church collects extensive data on its members, but secular scholars are usually not permitted to analyze them. Much of what is known about the religious behavior of Latter-day Saints comes from the work of scholars employed by the church (see, for example, Heaton 1998; Albrecht 1998; Cornwall 1998). Some information can be gleaned by examining Mormons in surveys of religious activity with large national samples, but these observations are too coarse for testing the market share thesis. However, the LDS Church occasionally releases general membership statistics to the public. These can sometimes be manipulated to compute proxy measures of religious activity. For example, membership statistics were used to compute the priesthood ordination rates in the test of the market share thesis discussed above.

Another source of membership statistics is the Religious Congregational Membership Study (hereafter RCMS). The RCMS is a census of church members and congregations in the United States. It is compiled every 10 years to coincide with the U.S. Census by the Association of Statisticians of American Religious Bodies (Jones, *et.al.* 2002). Participating denominations supply the RCMS with the number of adherents and the number of congregations they claim for each U.S. county. These data have been compared to other tabulations of religious bodies, and they are believed to be accurate (Lim 2013). The LDS Church supplied both the number of adherents and the number of congregations for each U.S. county in the 1980, 1990 and 2000 RCMS.<sup>1</sup> These figures can be combined to compute a measure of religious activ-

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<sup>1</sup> The church provided information on membership, but not on congregations in 1970. In 2010, the church changed the way it reported its membership to the RCMS, making it impossible to compare Mormons in this survey with any of the previous surveys (see Stack 2012; Bolding 2012).

ity that permits a test of the market share thesis. This measure is based on the unusual polity of Mormon congregations.

Mormon congregations are called “wards.” Wards are geographic units analogous to traditional parishes. Wards have no professional clergy, and are administered by lay volunteers who receive no compensation. Lay responsibilities are known as “callings,” and they are an essential feature of Mormonism. Callings give Mormons a stake in their congregation, and provide opportunities to serve others and acquire leadership skills. Every ward member capable of assuming a calling is expected to have one (Evans et al. 2013; Hammarberg 2013; Taber 1993). Because Mormonism is a growing denomination, when wards become too large to provide a calling for every active member, they are split. Splitting wards keeps the membership engaged, and preserves intimacy within the congregation.

Participation rates vary from ward to ward. All wards have stalwart members, but virtually all wards also have members who never attend church and do not have a calling. With few exceptions, the church keeps inactive members on ward rosters, even if they haven’t attended a meeting in years (Stewart 2007). Since every active ward member is expected to have a calling, and wards split when services become too crowded, it stands to reason that in areas where rates of Mormon religious activity are high there will be fewer members on ward rosters. By contrast, where rates of Mormon religious activity are low, there will be more members on ward rosters, because inactive members remain on the rolls, but neither occupy a pew nor assume a calling. Thus, *ceteris paribus*, smaller ward rosters evince higher rates of religious activity, and larger ward rosters evince lower rates. By examining the average number of members per ward in various geographic units, it is possible to compare the vitality of Mormonism in different locales (see Phillips 2006:61).

The average number of members per ward for U.S. counties can be computed from the RCMS by dividing the number of Mormons in each county by the number of wards in the county. The LDS Church’s market share can be defined as the percentage of the county’s residents belonging to the church. This can be determined by dividing the number of Mormons in the county by the county’s total population, obtained from the U.S. census. If the market share thesis holds, the average number of members per ward should decline as the LDS Church’s market share declines, and increase as its market share increases.

Before testing this hypothesis some caveats must be observed. Recall that a religious market is the aggregate of all the potential church members and all of the churches they may join in a particular

geographic unit. In rural counties with low population density, there may be too few churches within easy travelling distance to regard the county as a discrete religious market. Residents must be sufficiently concentrated within a county to facilitate competition between churches, and make the possibility of switching between them viable. (For a discussion of counties as religious markets, see Finke et al. 1996).

Determining the average number of Mormons per ward in rural counties presents a different problem. The relatively fixed size and geographic perimeters of wards means that in rural areas, a single ward might encompass parts of two or more counties. For administrative purposes, the LDS Church locates wards within the chapel they utilize. This would inadvertently reduce the average number of Mormons per ward in a rural county with a chapel if that chapel hosts wards with boundaries extending into adjacent counties.

One way to address these problems is to exclude counties that are unlikely to host functioning religious markets from the analysis. The United States White House Office of Management and Budget (2010) has developed a typology to designate counties as either “metropolitan,” “micropolitan,” or rural. A micropolitan county contains at least one town with 10,000 residents. These counties are likely to contain enough religious pluralism to meet the assumptions of the market share thesis, and to reduce the number of wards that straddle county lines. Thus, this analysis is limited to counties with at least 10,000 residents. In addition, this test of the market share thesis employs the 1980 RCMS, since the study that uncovered the Mormon exception to the market share rule used data from 1980.

## **Analysis and Findings, 1980**

The nature and strength of the association between Mormon market share and the average number of members per ward for each included county in the 1980 RCMS can be determined by computing Pearson’s product-moment correlation coefficient, or Pearson’s  $r$ . This statistic measures the linear dependence between two continuous variables. Variables that increase and decrease together have a positive relationship, whereas variables with an inverse correlation have a negative relationship. Values for Pearson’s  $r$  range from 1 (for a perfect positive relationship) to -1 (for a perfect negative relationship). When  $r$

is equal to zero, the variables have no relationship. A relationship between two variables is stronger the further the value of  $r$  is from zero.<sup>2</sup>

The correlation between LDS market share and the average number of members per ward in 1980 for 1399 counties with populations exceeding 10,000 residents was .208. The positive value of  $r$  means that as LDS market share increases, wards become larger. This result is statistically significant ( $p < .001$ ), and the odds that this pattern appears in the data by chance are less than 1 in 1000. This finding is consistent with the market share thesis, and suggests that religious activity among Mormons is highest—as determined by ward rosters with fewer members—where the church's share of the religious market is smallest.

This finding is based on data from wards across the nation. But could this overall correlation obscure a different dynamic in the few counties where Mormonism is a veritable monopoly faith? Recall that within Utah, religious activity was observed to be highest in the counties where Mormons were most densely concentrated. This anomalous finding was attributed to overlapping kin and church networks, and the conflation of religious and secular life. Can this finding be replicated with data from the RCMS?

In order for a Mormon subculture to suffuse kin, workplace, school, and community social networks, Latter-day Saints must be a large majority of the population. If such enclaves produce different sources of religious activity than those posited by the market share thesis, then the positive relationship between LDS market share and the average number of members per ward observed nationwide will flip and become negative for the counties where Mormons are very densely concentrated. In the 1980 RCMS there were twelve counties with over 10,000 residents where the LDS Church claimed over two-thirds of the population. All of these counties were in Utah and southeastern Idaho. The value of  $r$  representing the correlation between LDS market share and the average number of members per ward for these Mormon dominated counties is -.613. This strong negative correlation replicates and corroborates the study based on priesthood ordination rates. Despite the small number of counties in the analysis the result is statistically significant ( $p < .05$ ), and the odds that this pattern appears in the data by chance are less than 1 in 20. Unlike the pattern observed nationwide, in counties where the LDS Church predominates, religious activity increases as the Mormon subculture becomes more pervasive.

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<sup>2</sup> The Wikipedia entry for Pearson's product-moment correlation coefficient accurately explains this statistic.

## Analysis and Findings, 2000

The preceding analysis is based on data collected in 1980. Analyzing the 2000 RCMS can determine if the sources of religious activity observed in 1980 were still operating twenty years later. This twenty year span was a time of momentous change for the LDS Church. Between 1980 and 2000 the church added 2.5 million new members in the United States, making it one of the fastest growing large denominations in the nation (*Deseret News 1982 Church Almanac* 1981; *Deseret News 2001-2002 Church Almanac* 2000). Utah experienced significant population growth as well, and much of this was due to non-Mormons moving into the state (Toney and Kim 2006).

In order to manage rapid growth, the LDS Church made significant administrative changes. According to Armand Mauss, as the church began to transform from a regional subculture to an international denomination, it centralized and standardized its programs to make them more efficient (Mauss 1994). One goal of these changes was to make it easier for Mormons living outside Utah and the Intermountain West to practice their faith. For example, increasing access to temples was a top priority (Ostling and Ostling 2007:121-122). In January of 1980 the church had twelve temples operating in the United States. Mormons in Miami and Maine had to travel to Washington D.C. to attend the nearest temple. By the end of 2000, the church had dedicated 51 temples in various regions of the country.<sup>3</sup> Another important innovation was the implementation of a block meeting schedule. Before 1980, Sunday school classes and certain auxiliaries met on Sunday mornings, and the entire ward assembled for a 90 minute service later in the afternoon. The women's auxiliary and programs for children met during the week. In March of 1980, the church consolidated all of these meetings into a three hour block on Sunday. This greatly reduced the travel time for Mormons living where the church is scarce, and made attending worship services more convenient (Francis 1999:187). Finally, in 1990 the church began funding the operations of local wards with centralized tithing funds. Previously, wards raised their own money through the contributions of local members. Streamlining the process of funding ward budgets made the process of giving donations to the church easier, and made managing funds more efficient (Smith 1992:1543-1544).

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<sup>3</sup> Temple dedication dates are available online at: <http://www.ldschurchtemples.com/chronological/>

These administrative changes can be viewed through the lens of the market share thesis. The process of centralization and standardization transformed the church into a more competitive denomination. The evidence for this is rapid membership growth subsequent to these changes. Scholars have argued that these changes also foster a worship experience and denominational ethos that is uniform across political and cultural boundaries. This gives rise to a common cliché among Mormons: “The church is the same wherever you go.” (Cleverley 1996)

How has the centralization and standardization of Mormonism affected the relationship between LDS market share and religious activity? This can be determined using data from the 2000 RCMS. The correlation between LDS market share and the average number of members per ward in 2000 for 1624 counties with populations exceeding 10,000 residents was .107. The relationship between the variables is weaker than it was in 1980, but it is still statistically significant ( $p < .001$ ), and the odds that this pattern appears in the data by chance is less than 1 in 1000. Twenty years later, religious activity among Mormons is still highest where their share of the population is smallest.

Even though many of the administrative changes discussed above were designed to assist a rapidly dispersing church, all of these changes were implemented in Utah and places in adjacent states where Mormonism is the predominant faith. In many Utah towns, most Latter-day Saints live within easy walking distance of their chapel. Nevertheless, the three hour block schedule—which was designed in part to cut the time and cost of travel—was implemented in these towns as well. I have argued that these administrative changes increased the LDS Church’s competitiveness in pluralistic religious markets. How have these changes impacted dense Mormon enclaves where church and kin networks are consolidated, and religious and secular life overlap?

In the 2000 RCMS there were sixteen counties with over 10,000 residents where the LDS Church claimed over two-thirds of the population. Once again, all of these counties were in Utah and southeastern Idaho. The value of  $r$  representing the correlation between LDS market share and the average number of members per ward for these counties is -.001. Unlike 1980, in 2000 there was no relationship between LDS market share and religious activity in Mormon dominated counties. This is displayed in the scatterplots in Figure One. The negative correlation between the variables in the 1980 RCMS is clearly evident from the trend line in the scatterplot, whereas the trend line for the correlation in the 2000 RCMS is flat.

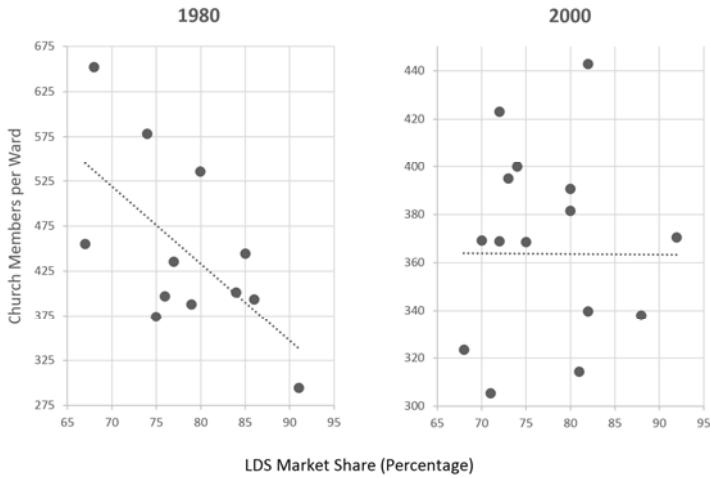


Figure 1. LDS market share and average ward size in Mormon majority counties

It is interesting to note that while the pronounced negative correlation between LDS Church market share and the average number of members per ward observed in 1980 was no longer evident in 2000, overall levels of religious activity in Mormon dominated counties increased over the course of this twenty year period. As Table 1 demonstrates, the average number of members per ward in counties with a large Mormon majority fell from 446 in 1980 to 364 in 2000. Moreover, there was less variability in the size of wards in 2000 than there was in 1980. The standard deviation for wards dropped from 99 members per ward in 1980 to just 42 members per ward in 2000. Hence, the counties where Mormons were most densely concentrated were uniformly more active in 2000 than they were in 1980. A t-test for two independent means comparing the average number of members per ward in these counties for 1980 and 2000 shows a statistically significant difference between the two means, and the odds that this difference is due to chance alone are less than one in 100 ( $t=2.98$ ,  $p<.01$ ).

Table 1: Ward Structure in LDS “Monopoly” Counties		
	1980	2000
Average number of members per ward	446	364
Standard deviation	99	42
Number of cases	12	16

## Discussion

Why did a strong relationship between the LDS Church's market share and levels of religious activity evaporate in dense Mormon counties between 1980 and 2000, and why did religious activity increase and become more uniform in these counties? One possible answer is that the administrative changes implemented by the LDS Church had a strong impact among the Latter-day Saints in Utah and Mormon dominated areas in adjacent states, and this impact augmented and levelled the influence of the existing religious subculture in the region.

As the LDS Church became more dispersed through rapid growth, the church increased its emphasis on self-control and obedience to church leadership as a strategy for living a strict Mormon lifestyle in a secular, pluralistic society (Hammarberg 2013; Mauss 1994; Phillips 2001). Perhaps this emphasis on self-control merged with the mechanisms of social control operating in Utah's LDS enclaves. The combined effect of the church's denominational ethos and the existing regional subculture could explain why church activity in the region seems to have increased, and become less variable. However, additional study and additional sources of data are necessary before scholars can draw firm conclusions regarding the effects of market share on the religious behavior of Latter-day Saints.

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# **A Cross-Sectional Study of the Social-networking Behaviors of Electronic Cigarette E-Forum Users**

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## **ABSTRACT**

*Electronic cigarettes (e-cigarettes) are gaining in popularity at a time when the understanding of the health hazards is not established. It is important for public health professionals to better understand how and what information is being disseminated to correct non-evidence-based and potentially misleading information. This study was designed to provide a better understanding of the social-networking habits of e-cigarette users who visit online e-cigarette forums. E-cigarette users were recruited from the “e-cigarette forum” website and completed an online survey inquiring about their use of Facebook, Twitter, and other social-networking websites. The survey inquired about participants’ e-cigarette postings to each site and whether their posts portrayed an e-cigarette as positive, neutral, or negative. A total of 154 surveys were completed. Approximately 89% of respondents had created Facebook accounts, and 86% of those who posted comments to Facebook posted positively regarding e-cigarettes. Twitter accounts were reported by 55% of respondents, and 87% of those who posted indicated their posts*

*were positive. YouTube was visited by 93% of respondents, and 94% of those who posted reported the posts as being positive. Possession of an account on another social-networking website was reported by 19% of respondents, and 100% of those who posted reported positive postings. Social media is popular among e-cigarette users who visit online e-cigarette forums. Many users tend to post positive information regarding their e-cigarette use. Understanding this behavior better allows professionals to prepare themselves for correcting potentially misleading information presented on these sites.*

## INTRODUCTION

Electronic cigarettes (e-cigarettes) are a new product and growing in use. According to King et al. (2013), the “ever” use of e-cigarettes increased from 3.3% in 2010 to 6.2% in 2011. The device consists of three primary parts: a battery, an atomizer, and a nicotine cartridge. The user inhales through the cartridge, triggering the atomizer to vaporize the nicotine liquid, which is then inhaled by the user. Unfortunately, e-cigarettes and the nicotine e-liquid contained in them are currently not regulated by the U.S. Food and Drug Administration in production, purity of ingredients, and marketing (O’Connor 2012). Consequently, consumers are not informed of the potential risks of using them, how much nicotine and other chemicals they are exposed to, and whether there is a benefit to using them versus conventional cigarettes (United States Food and Drug Administration 2014).

While no studies regarding the long-term effects of e-cigarette use have been published, a few studies have considered the effects of short-term exposure to nicotine and other potentially dangerous chemicals in e-cigarettes. Etter and Bullen (2011b) measured cotinine levels (the by-product of nicotine metabolism) in e-cigarette users and found those who used e-cigarettes daily had a median cotinine level of 322 ng/mL. The authors concluded users were obtaining similar levels of nicotine and cotinine as cigarette smokers. Goniewicz et al. (2014) examined chemicals other than nicotine in e-cigarette vapor. Results indicated levels of formaldehyde, acetaldehyde, acrolein, toluene, tobacco-specific nitrosamines, and metals such as cadmium, nickel, and lead. This research suggests that short-term exposure to toxic chemicals occurs during e-cigarette use. Since the long-term effects of these products are unknown, it is important to be cautious when discussing (online or in person) the potential benefits or risks posed by these products.

Many Americans use at least one social-networking website and have accounts on more than one site. Websites such as Facebook, Twitter, YouTube, and many more have allowed people to share their thoughts and opinions about every issue imaginable, including e-cigarettes. Only a few studies such as those by O'Connor (2012), Phua (2013), and Yamin et al. (2010) have examined the relationship between social-networking and e-cigarettes.

O'Connor (2012) analyzed various message boards and forums regarding e-cigarettes. These sites allow users to discuss the product, obtain information, and share experiences. The product may be more widely disseminated through this approach compared with other channels. Phua (2013) addressed the role of social-networking sites on smoking cessation. The article concluded active participation on social-networking sites had many positive impacts such as interconnectedness and emotional bonding to the group of users. Those who regularly used these sites held similar attitudes and behaviors. Social-networking sites allow members to develop trust, self-disclosure, and emotional attachment to the group. This results in a system of social support with members who are going through the same experiences. The author concluded that through active participation in social-networking sites, people can feel empowered and exert more control over their struggle with smoking cessation.

E-cigarette companies also use social media as a means to market their product and recruit new users. According to Yamin et al. (2010), many e-cigarette users act as salespeople for the product and earn profits for recruiting new users. This has been an effective marketing scheme because early adopters of the product are highly influential in promoting e-cigarettes (O'Connor 2012). Yamin et al. (2010) concluded that potential harm to consumers' health increases by having consumers also acting as distributors, because little is known regarding the health effects of e-cigarettes.

Because of the lack of information on e-cigarettes, including the perceptions and social-networking behaviors of users, marketing tactics, and health effects, further research on the use of these devices is well warranted. The Examining E-Cigarette Initiation and Growth (EE-CIG) study considered whether the use of electronic cigarettes indicates that similar characteristics exist among users. The study was designed to provide information related to e-cigarette users' awareness of e-cigarette marketing, personal use of nicotine-delivery devices (including e-cigarettes), perception of e-cigarettes, and social-networking habits. The following research question guided the social-networking portion of the EE-CIG study: "Do e-cigarette users who use electronic forums post positively via social-networking regarding their e-cigarette

use?” The following is a description of the methods, results, and conclusions related to this portion of the EE-CIG study.

## METHODS

### *Sample*

The EE-CIG study used a convenience sample of e-cigarette users recruited via the e-cigarette forum website ([www.e-cigarette-forum.com](http://www.e-cigarette-forum.com)). Researchers created new threads under several areas of the site soliciting volunteers and offering to enter participants into a drawing for a \$40 gift card. Data collection continued for a two-week period, and email addresses were collected to enter participants into the drawing and to include a level of verification to prevent duplicate surveys from the same individual. Since the study aimed to describe the general electronic cigarette online forum-using population, no additional eligibility criteria were included. The study was approved by the Utah Valley University Institutional Review Board (approval #01184).

### *Instrument*

The EE-CIG survey was created based on studies by Choi and Forster (2013), Etter (2010), Etter and Bullen (2011a,b), Foulds et al. (2011), King et al. (2013), McQueen et al. (2011), Pearson et al. (2012), and Sutfin et al. (2013), including some questions adapted directly from the Study to Prevent Alcohol-Related Consequences (Wolfson et al. 2012). Ninety-five questions were created, of which 25 focused on social-networking habits. The survey was administered via the Qualtrics online survey tool. Participants were presented the informed-consent document in the survey header and provided implied consent by responding to one or more survey questions.

Participants spent an average of 15 minutes completing the survey and were asked the following questions:

1. Do you have a Facebook/Twitter/YouTube/Other social-networking account (yes/no)?
2. When was the last time you were on Facebook/ Twitter/YouTube/Other social-networking account (in the last 24 hours; in the last 7 days but not within the last 24 hours; in the last 30 days but not within the last 7 days; in the last 12 months but not within the last 30 days; more than 12 months ago)?

3. In the past 30 days, have you posted anything on Facebook/ Twitter/YouTube/Other social-networking account related to e-cigarettes (yes/no)?
4. Did your post portray e-cigarettes in a positive, neutral, or negative way (positive; neutral; negative)?
5. Have others in your social network on Facebook/Twitter/ YouTube/Other social-networking account posted anything related to e-cigarettes (yes/no)?
6. Did that post(s) mainly portray e-cigarettes in a positive, neutral or negative way (positive; neutral; negative)?

## RESULTS

One hundred ninety-five surveys were completed over the two-week timeframe, 154 of which were completed almost entirely (e.g., at least 95% complete). All data was range- and contingency-checked for discrepancies and none were found. A summary of demographics is presented in Table 1.

The sample average age was 47 years, with a range of 22 to 74 years. The sample was predominantly Caucasian/White (96.7%), with 1.3% indicating multiracial background and 2.0% reporting that they did not know their racial background. Similarly, the sample was largely Non-Hispanic (96%), with only 1.3% indicating Hispanic ethnicity and 2.7% specifying that they did not know their ethnicity. Ninety-seven percent reported current use of e-cigarettes (using the devices within the past 30 days), while 96.7% reported using e-cigarettes containing nicotine and 2.3% using e-cigarettes without first using traditional cigarettes. Data were not collected regarding how long respondents had been members of this particular electronic cigarette e-forum.

### *Facebook*

Facebook accounts were reported by 89% of respondents, and 99.2% of those account holders accessed their accounts within the past 30 days. Almost 88% (87.5%) of those who had accessed their accounts within the past 30 days had posted something to Facebook regarding e-cigarettes. Furthermore, 85.6% of respondents who posted something related to e-cigarettes reported those posts as portraying e-cigarettes positively, while 13.6% reported neutral posts and only 0.8% reported negative posts. Eighty-six percent of those who had accessed their Facebook accounts within the past 30 days had friends in their social network who had posted comments to Facebook regarding e-cigarettes. Approximately 87% (87.2%) of those friends' posts described e-

cigarettes positively versus 12.0% and 0.9% as being neutral or negative, respectively.

<b>Table 1. Participant Demographics</b>	
<b>Characteristics</b>	<b>n (%)</b>
Gender	
Men	99 (64.3)
Women	52 (33.8)
Did not respond	3 (1.9)
Race	
Caucasian or White	146 (94.8)
Multiracial	2 (1.3)
Don't know	3 (1.9)
Did not respond	3 (1.9)
Ethnicity	
Hispanic	2 (1.3)
Non-Hispanic	143 (92.9)
Don't know	4 (2.6)
Did not respond	5 (3.2)
Relationship Status	
Single without steady partner	20 (13.0)
Single with steady partner	31 (20.1)
Married	79 (51.3)
Separated/divorced	19 (12.3)
Widowed	2 (1.3)
Did not respond	3 (1.9)
Religious Affiliation	
Atheist or agnostic	56 (36.4)
Non-denominational Christian	24 (15.6)
Protestant	21 (13.6)
Catholic	18 (11.7)
Other	28 (18.2)
Did not respond	7 (4.5)

### *Twitter*

Compared with Facebook, the number of respondents with Twitter accounts was substantially lower. Nearly 55% (54.9%) of respondents reported having a Twitter account, and 90.3% of account holders reported accessing the account within the past 30 days. Eighty percent of those accessing their Twitter accounts within the past month speci-

fied they had posted something related to e-cigarettes. Additionally, 86.7% of those who had posted regarding e-cigarettes indicated their posts portrayed e-cigarettes positively compared with 13.3% reporting neutral posts and no respondents reporting negative posts. Eighty-eight percent of the respondents who had accessed their Twitter accounts within the past 30 days reported friends in their social network had posted to Twitter regarding e-cigarettes. Approximately 85% (84.8%) of those friends' posts portrayed e-cigarettes positively as opposed to 15.2% and 0% reported as being neutral or negative, respectively.

### *YouTube*

Nearly 51% (50.6%) of participants reported having a YouTube account. YouTube does not require visitors to sign up for an account to view the videos so having a YouTube account was not as important compared with Facebook and Twitter where a user must have an account to post comments or view others' posts. All participants were surveyed regarding how long it had been since they had last accessed the site. Approximately 93% (92.7%) of respondents reported visiting the YouTube website within the past 30 days; however, very few (16.5%) posted regarding e-cigarettes. Regarding the small number who posted comments/videos related to e-cigarettes, 94.1% reported those posts were positive compared with 5.9% reporting neutral posts and no respondents indicating negative posts. Sixty-one percent of the sample indicated that friends in their social network posted comments/videos to YouTube regarding e-cigarettes. Almost 85% (84.5%) of those friends' posts described e-cigarettes positively as opposed to 15.5% reporting neutral posts and no respondents indicating negative posts.

### *Other Social-Networking Accounts*

The proportion of participants with one or more additional social-networking accounts was 19%. Examples of these accounts included LinkedIn, Google+, Pinterest, WordPress, Tumblr, Instagram, Yahoo Groups, and various e-cigarette forums/blogs. Occurrence of these accounts was low. All participants (100%) who had one or more additional accounts reported accessing the account within the past 30 days, and 55.2% of those individuals reported posting something related to e-cigarettes. One hundred percent of those who had posted reported these posts as portraying e-cigarettes positively. Sixty-six percent of those with one or more additional accounts reported that others in their social network posted comments regarding e-cigarettes. Approximately 95%

(94.7%) of those friends' posts were positive compared with 5.3% neutral and no respondents reporting negative posts.

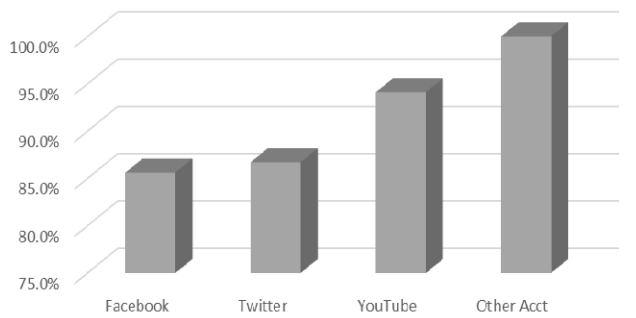


Figure 1. Percentage of account holders posting positively regarding e-cigarettes.

Figure 1 depicts the percentage of account holders who posted positively regarding e-cigarettes. Other social-networking account holders were most likely to post positively (100%), while Facebook account holders were least likely to post positively (85.6%).

## DISCUSSION

### *Conclusions*

Results of this study indicate the use of social media is very popular among e-cigarette users who visit online e-cigarette forums. Specifically, Facebook is very popular among this population. It is important to recognize the high percentage of this population who use this platform to post positively regarding the use of e-cigarettes. Two-thirds of study respondents indicated posting positive comments regarding e-cigarettes on Facebook, while smaller numbers reported posting to other sites such as Twitter, YouTube, LinkedIn, etc. Coupling these numbers with the high percentages of respondents who reported having friends in their social network who posted positive e-cigarette comments indicates the pervasiveness of this phenomenon across various social-networking websites. Results indicate e-cigarettes are discussed online and in positive terms. Many who read these posts are being exposed to information based on anecdotal evidence rather than scientifically supported information. For example, a respondent may have posted regarding a successful attempt at smoking cessation

through the use of e-cigarettes. Little scientific evidence exists at this time to justify potentially misleading claims such as this.

It is important to understand these findings. Understanding the social-networking habits of this population allows public health professionals to better understand the source of potentially misleading e-cigarette information received by the general public via social media. This understanding allows educators to better correct misleading information presented.

### *Limitations*

Several limitations were encountered during the study process. Participants consisted only of visitors to the e-cigarette forum who are already familiar with the use of the internet. This has the potential of artificially inflating the number of e-cigarette users using social media and results in a restricted ability to generalize the results to other e-cigarette-using populations. Further study is necessary and should sample e-cigarette users using a variety of methods to obtain a more representative sample of the e-cigarette-using population.

Questions regarding positive, neutral, and negative posts did not specify what each of these labels meant and therefore relied upon participants' recall and self-reporting of their posts and their judgment of the tone/message of those posts, both of which are subject to potential bias. Without knowing what the posts actually said, it is difficult to determine whether misinformation was presented. Future research should use specific criteria to examine the posts themselves and determine the tone/message presented.

Participants were not instructed regarding how to reply to these questions if they had posted multiple times regarding e-cigarettes. Respondents may have posted positively and negatively but were restricted to one response, potentially skewing the data. Future research should allow respondents to specify what proportion of their posts were positive, neutral, or negative.

### *Recommendations for Future Research*

Social media is a fast-paced evolving entity, constantly providing new opportunities for research and discovery. New websites are being created, allowing e-cigarette users more possibilities for sharing information regarding the use of these devices. Future research should evolve in parallel with social media, collecting data regarding the use of these new websites. Future research should also address the limitations discussed above, including the recruitment of e-cigarette users from locations other than e-cigarette forums, collection of the actual e-

cigarette-related posts to determine the tone/message presented, and adjusting questions to gather data regarding the proportion of positive, neutral and negative posts.

## ACKNOWLEDGMENTS

The authors acknowledge the assistance of the e-cigarette users who completed the assessment, not only for doing so, but for providing feedback regarding the structure of the questions and survey.

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# Abstracts

## BIOLOGICAL SCIENCES

### **Genome analysis of two *Lactobacillus curvatus* strains**

**Craig Oberg, Taylor S. Oberg, Jeff R. Broadbent, Michele D. Culumber, Donald J. McMahon, Matthew J. Domek, & James L. Steele**

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Recent studies concerning cheese microbiology have revealed *Lactobacillus curvatus* has become an increasingly common component of non-starter lactic acid bacteria (NSLABs) populations in aged Cheddar cheese. We recently sequenced the genome of two *Lb. curvatus* strains, WSU1 and LFC-1, with annotation performed using RAST. Initial genetic comparisons between the predicted coding sequences showed WSU01 had 312 unique predicted proteins and LFC-1 had 297 unique proteins using a 90% amino acid identity threshold. Both strains have genes encoding enzymes for cellobiose utilization and the ability to ferment ribose and N-acetylglucosamine. Further analysis showed that LFC-1 also has genes that encode enzymes for maltose and trehalose fermentation and citrate utilization. Both genomes contain genes for a putative sakacin-like bacteriocin and genes for a propanediol utilization pathway. Our results reveal the presence of a sakacin-like bacteriocin gene SppA, an immunity protein gene, SpiA, and genes, SppR and Sppk, for a two-component signaling system for bacteriocin regulation. Both strains were tested for bacteriocin activity against 10 strains of lactic acid bacteria (LAB) and 3 strains of non-LAB by the agar flip technique. Three strains of the LAB were inhibited as were *Listeria inocula* and *Salmonella typhimurium*. These factors may contribute to the ability of *Lb. curvatus* to dominant the NSLAB biota of aged cheese.

## BIOLOGICAL SCIENCES

### **Extraction of extracellular DNA with novel surfactants**

**Derek Harris & Aimee Newsham**

*Dixie State University*

The presence of extracellular DNA (eDNA) in various environmental and biological media has become the subject of growing interest in the field of research. In media such as bacterial biofilms, it has been shown to play a vital role in their structure and antimicrobial properties. Existing methods for extraction of pure eDNA from these media are complex and problematic; particularly from biological media where cells containing genomic DNA are also present. Novel surfactants have been developed whose miscibility and polarity are easily tuned to suit a variety of conditions necessary for eDNA extractions. They can accomplish extraction of pure eDNA through concurrent hydrophilic and hydrophobic interactions in a single step, while remaining unreactive with the surrounding media or lysing cells and exposing genomic DNA. We have shown by spectrophotometric quantification that these surfactants extract measurable amounts of DNA into a water-immiscible solvent layer, which can then be removed from the media. The DNA can then be further amplified and purified for analysis. Further refinement of extraction methods utilizing these surfactants could prove a tremendous asset to research attempting to elucidate the possible genetic content of eDNA and the mechanisms behind its often crucial role in environmental and biological media.

## BIOLOGICAL SCIENCES

### **Edge effect of mycorrhizal infection occurrence in *Gutierrezia sorothrae***

**Shannon Call**

*Weber State University*

Mycorrhizas are mutualistic fungi with vascular plants. Mycorrhizal associations are important for plants as they provide minerals, especially phosphorous, while the plant provides carbohydrates for the fungi. Edges affect plant community diversity by altering water runoff and soil moisture or encouraging invasive species growth. Because

edges impact plant communities, I hypothesized that mycorrhizal colonization may decrease as distance to a trail edge decreases. To test this hypothesis, *Gutierrezia sarothrae* was sampled from two sites and three distances: 1, 10, and 20 meters from an edge. Mycorrhizal colonization occurrence was determined. Statistical difference was determined using chi-square analysis. There was a significant difference in mycorrhizal associations between 1 m to 10 m ( $p < 0.01$ ) and 10 m to 20 m ( $p < 0.005$ ). Upon completion, photographs showing the existence of an old hiking trail were discovered, adding further support to the hypothesis. Results showed differential mycorrhizal colonization frequency, suggesting a negative response near trail edges.

## BIOLOGICAL SCIENCES

### Micropropagation of *Capsicum annum*

**Toma Todorov, Samantha Beck, & Olga Kopp**

*Utah Valley University*

Three different varieties of *Capsicum annum*, Cayenne, Jalapeño, and Thai, were grown in vitro to evaluate induction of embryogenesis and/or morphogenesis. *C. annum* is a food crop with medicinal properties. It produces Capsaicin, a chemical that has been approved by the U.S. Food and Drug Administration for treating pain; it has antioxidant properties that can help fight the carcinogen nitrosamine and has shown anti-tumor activity in colon cancer studies. In-vitro culture is an alternative to overcome the problems of secondary metabolite production in field-grown plants that have pharmacological value. In addition, culture suspension can result in the production of novel secondary metabolites or increase the secondary metabolites of interest, in this case Capsaicin. Their ability to respond to varying concentrations of four different hormones was tested; two of these had no effect on callus growth. The effect of aqueous fruit extract on the callus growth will be presented.

## BIOLOGICAL SCIENCES

### Microbial screening of potable water sources in Guatemala

**Emma Bentley, Craig Oberg, Karen Nokaoka, Matthew Domek & Michelle Culumber**

*Weber State University*

Transmission of diseases by fecally contaminated water represents a reoccurring health risk for locals and travelers in developing nations. In this study, the degree of microbial, along with fecal, contamination in potable water was determined by screening 27 samples collected in 4 locations across Guatemala. Samples of potable water, taken in urban and rural areas from commercial facilities to single-dwelling spigots, were plated on aerobic count, enterobacteriaceae, and *E. coli*/coliform Petrifilms. Inoculated Petrifilms were incubated for 48 h and then enumerated. Results showed 92% of sources contained bacteria, 48% contained coliforms, 15% indicated *E. coli*, and 71% were positive for Enterobacteriaceae, indicative of *Salmonella*. Coliform counts ranged from 0 to  $>1.6 \times 10^2$  per ml of potable water. Confirmation of *E. coli* and Enterobacteriaceae required harvesting isolates from Petrifilms. Three methods were used: aseptic scraping, picking colonies, and stamping with Rodac plates. Thirty isolates were confirmed on EMB agar and 24 isolates by 16S rRNA sequencing. No *Salmonella*, *Shigella*, or *E. coli* were identified; however, organisms causing diarrheal diseases were found, including *Citrobacter freundii*, *Aeromonas hydrophila*, *A. caviae*, and *Plesiomonas shigelloides*. Although rarely associated with diarrhea in the U.S., these organisms may be prevalent in Guatemala. Results indicate potable water sources could be a significant source of fecal pathogen transmission.

## BIOLOGICAL SCIENCES

### Survey of Great Salt Lake Virosphere

**Kayla Blackford, Matthew J. Domek & Craig J. Oberg**

*Weber State University*

Viruses are the most abundant biological entity on the planet, yet the virosphere remains largely unexplored. Recent studies have investigated the interactions between viruses (bacteriophages) that infect four

genera of bacteria (Halomonas, Idiomarina, Marinobacter, and Salinivibrio) isolated from the Great Salt Lake (GSL). Bacteriophages play an important role in controlling bacterial populations and nutrient recycling, but little is known concerning the impact of seasonal changes in temperature, salinity, and nutrient availability on the GSL virosphere. In this study, we are trying to develop methodology to survey the virosphere and its diversity. GSL water samples were taken monthly, filtered to remove bacteria, and then ultra-centrifuged to concentrate bacteriophage. Three methods are being developed to enumerate the concentrated samples: spot testing on known hosts, transmission electron microscope examination of phage morphologies, and lysis curves using automated spectrophotometry. Spot plating had detected phage specific to known hosts, and a panel of phage morphologies is being developed. Lysis curves show the most promise since phage enrichment can be done as a preliminary step prior to detection. Little is currently known about concerning the impacts bacteriophage have on the lake's ecosystem. Understanding the GSL virosphere can lead to better methods of maintaining a healthy lake, especially with the human presence near the lake.

## BIOLOGICAL SCIENCES

### **Isolation of novel lactic bacteria from Italian pasta filata cheeses**

**Craig Oberg, Nicholas DeYoung, & Michele Culumber**

*Weber State University*

The most important characteristic of pasta filata cheese, commonly called mozzarella in the United States, is its texture, particularly when heated. New uses for pasta filata cheese may require more flavor development during storage, specifically if it is to be consumed uncooked. Three pasta filata (mozzarella) cheeses, Treccia salata, Scamorza, and a fresh mozzarella, all manufactured in Italy, were homogenized in sterile 2% sodium citrate and plated on MRS, MRS + 1% sorbitol (pH 5.2), Ellikers, and M-17 agars. Inoculated plates were incubated at either 37°C or 25°C for up to 7 days. Individual colonies were picked off at 2-day intervals, grown in the appropriate broth, then quadrant streaked to determine purity. DNA was extracted from isolates, and 16S rRNA genes were amplified by PCR, using bacteria-specific primers, and then sequenced. Mozzarella manufactured in the U.S. is most commonly made using *Streptococcus thermophilus* and

either *Lactobacillus delbrueckii* ssp. *bulgaricus* or *Lactobacillus helveticus*; however, isolates from the three Italian pasta filata cheeses did not contain these lactic acid bacteria. Instead, *Leuconostoc mesenteroides* subsp. *mesenteroides*, *Lactobacillus casei*, and subspecies of *Lactobacillus delbrueckii* including *indicus*, *lactis*, and *delbrueckii* were found. Many of these have been associated with the production of flavor compounds in cheese during aging and could be used as flavor adjuncts in aged pasta filata cheese.

## BIOLOGICAL SCIENCES

### Infectivity of bacteriophage isolated from the Great Salt Lake is altered by pH

Randy Olson & Matthew J. Domek

Weber State University

Viruses play a role controlling microbial populations and nutrient recycling. Recent studies have investigated the interactions between viruses (bacteriophages) that infect bacteria isolated from the Great Salt Lake (GSL). When a bacteriophage successfully infects a bacterial cell, lysis occurs and a decrease in the turbidity of the broth culture is observed. The objective of this study was to investigate the effects of pH on bacteriophage infection and host lyses. We followed cell growth and cell lysis by measuring absorbance at 600 nm. We also attempted to correlate lysis with the bacteriophage plaque assay. The bacterial hosts (*Idiomarina* strains SA3A and SA11, originally isolated from the GSL) were routinely grown in halophilic media (HM) at pH 7.5. To test the effect of pH, HM was buffered with MES or TRIS and adjusted to pH 5.5, 6.5, 7.5, or 8.5. SA3A grew well at all pHs but best at pH 6.5 and 7.5; however, lysis by the bacteriophage was inhibited at pH 5.5. SA11 showed a different growth pattern: It grew best at pH 7.5 and 8.5 and not at all at pH 5.5. Lysis occurred at pH 6.5, 7.5, and 8.5. The GSL has a pH of approximately 8.0. Together, these results suggest that some bacteriophage/host pairs maybe more strictly adapted to the pH of GSL environment; however, more work is needed to understand how changing the pH alters infection and lysis of hosts.

## BIOLOGICAL SCIENCES

### **Salt conditions affect bacteriophages infectivity of *Salinivibrio costicola***

**Tyler Allen & Matthew J. Domek**

*Weber State University*

*Salinivibrio costicola* is a halophilic bacterium that has been isolated from a variety of saline environments including the Great Salt Lake (GSL). Previous studies have identified two strains (SA36 and SA39) of *S. costicola* that can be infected by bacteriophages DB01 and NS01, respectively. The objective of this study was to investigate the effects of pH and salt content on phage infection and host lysis. Absorbance, measured by spectrophotometry, was used to monitor cell growth and cell lysis caused by the phage. The bacterial hosts were routinely grown in halophilic media (HM) containing 8% NaCl, 1% MgSO<sub>4</sub>, and 0.5% KCl at pH 7.5. The effects of salt content were tested using HM made with the following adjustments to the standard recipe: NaCl +MgSO<sub>4</sub>, NaCl + KCl, or NaCl alone. NaCl concentrations were adjusted to maintain the osmotic balance of HM. To test pH, HM was buffered with MES or TRIS and adjusted to pH 5.5, 6.5, 7.5, or 8.5. Both *S. costicola* hosts grew well in all media conditions. Phage DBO1 caused lysis under all conditions, indicating that variations in salt and pH do not impact infection or lysis by this phage. NS01, however, appears to require MgSO<sub>4</sub> for lysis. Further, NS01 did not cause lysis at pH 8.5. The GSL has a pH of approximately 8.0, and MgSO<sub>4</sub> is an abundant salt in the lake. Together, these results suggest that NS01 maybe more strictly adapted to the GSL environment than DB01; however, more work is needed to understand how changing the environmental conditions alters the interactions between the hosts and the phages.

## BIOLOGICAL SCIENCES

### **Co-occurrence of endophytes and aphid galls in cottonwood trees**

**Julia Brough Hull & Ron J. Deckert**

*Weber State University*

Endophytes are fungi that live within aerial portions of plants for most or all of their life cycle without causing visible signs of disease. Gall-

forming aphids are highly competitive over gall site selection, forming galls on leaves of narrowleaf cottonwoods. The favored gall location overlaps highest endophyte probability. I hypothesized a negative correlation between endophyte infection and aphid galling on leaves of hybrid cottonwood trees. I tested my hypothesis by obtaining samples of six hybrid cottonwood trees along the Weber River in northern Utah. Leaf samples of galled and ungalled leaves and corresponding twigs from current and previous years were sampled. Samples were surface sterilized, aseptically plated, incubated at room temperature for four weeks, and scored every two days for endophytes. Significantly more endophytes were associated with galled leaves than those without. Aphids may seek areas with high endophyte infections, or aphids themselves are introducing endophytes into leaves.

## **BIOLOGICAL SCIENCES**

### **Do canyon tree frogs in Zion National Park possess a mechanism to defend against Chytrid?**

**Carson Ence, Chelsea Moody, & Curt Walker**

*Dixie State University*

A relatively new pathogen, Chytrid fungus, has been a major cause of decline in amphibians worldwide. This pathogen has been found on canyon tree frogs in Zion National Park. Earlier data suggested that Chytrid did not affect populations of canyon tree frogs in Zion National Park. We predicted that since the populations were not impacted by the presence of the fungus, there must exist a mechanism by which the frogs rid themselves of the infective agent. To test this prediction, we captured and swabbed 10 frogs in each of 9 canyons in Zion National Park during the summer of 2013. Swabs were sent to San Diego Zoo to be analyzed for the presence of Chytrid DNA. Chytrid infection rates and population sizes were compared with data from previous years. As expected, the data showed that 2 of the 3 infected canyons experienced declines in the percentage of frogs infected with Chytrid. Thus, these frogs must use a mechanism to survive this worldwide pathogen where as other amphibians have not. This could be an insight for biologists worldwide to understand how amphibians can survive this pathogen.

**BUSINESS****Service Learning Outcomes Assessment****Jonathan Westover***Utah Valley University*

Rooted in Dewey's (1938) educational philosophy of "learning by doing," five major stakeholders of service learning pedagogy are generally recognized: students, faculty, the university, the community client, and the community at large (Workman and Berry 2010). As academia increasingly moves toward a business model of requiring not only meaningful outcomes from our work but also the effective measurement and assessment of return on our investments, the process of "closing the loop" in service and engaged learning demands the identification of relevant constructs and the development of their effective measures. The purpose of this presentation is to open a dialogue and facilitate exchanges among academicians toward the identification of major service and engaged learning outcome constructs and the development of effective assessment measures.

**BUSINESS****Assessing the Effectiveness of Hybrid Learning in Management Courses****Jonathan Westover***Utah Valley University*

This presentation will examine the role and effectiveness of hybrid, or blended, learning course offerings within the higher education context. Providing a brief review of the growing body of academic literature on the effectiveness of the hybrid model, this presentation will also explore models for evaluating the effectiveness of hybrid learning courses. Finally, this presentation will provide a brief look at two distinct hybrid courses: one lower-division college algebra course and one upper-division human resource management course. The strengths and weaknesses of these hybrid courses will be assessed and discussed alongside recommendations and a brief proposal for continued academic research examining hybrid course assessment best practices.

## **BUSINESS**

### **Learning the layers of culture: Gastronomic Anthropology in management**

**Shayla Macaffrey**

*Westminster College*

This paper explores the politically bounded assertions of cultural typology theories. It asserts that a better perspective may be necessary to explain, predict, and control managerial operation through the exploration of cultural convergence and divergence theory as it relates to culturally bounded favorite foods as well as the types and techniques of the culinary arts that indicate it is certainly worthwhile to understand cultural practices and culture. It is similarly necessary to understand the folkways of culture and the lowering boundaries to cultural cuisine. Discussed are international managerial practices, the necessity of a broader cultural understanding that transcends political boundaries, and the social facilitation and social learning of culture through food. Convergence theory asserts that cultures converge in gastro-economic inclusion through the rise of multinational food brands and fusion cuisine, while divergence theory postulates that ingredients and techniques spread for economic and cultural reasons. An example of this would be the spread of Tandoor-style cooking from Hindu to Islamic and Christian cultures. Examples from approximately 25 countries are offered for this contribution where spread of food, techniques, ingredients, and fusion are explored. Finally, some implications for managerial understanding of cultural distance are explored with suggestions for future research.

## **BUSINESS**

### **Why so selfish? An alternative perspective on negotiation and negotiators**

**M-C Ingerson**

*The Wheatley Institution*

There is a viable alternative to always assuming psychological egoism in negotiators and negotiations. This alternative assumptive worldview reconceives negotiators and negotiations as moral agents strongly relating with other moral agents. This ethical reconception is radically dif-

ferent from ontologically individual negotiators reactively using (and possibly abusing) other negotiators solely based on achieving arbitrary and capricious self-gratifying ends in amoral negotiation relationships. With this radical reconceptualization of negotiators and negotiations, success can then be expanded from merely seeking to claim economic resources and psychological satisfaction to meaningfully creating valuable agreements that build personal reputations of integrity and respect, strengthen mutual relationships within and between organizations, and encourage societies pursuing sustainable economic goals. Of course, future empirical research would be most helpful in testing the theoretical claims made here.

## **BUSINESS**

### **The half-life of organizational intervention in Latin America**

**Douglas Peterson**

*Westminster College*

Organizational interventions to improve productivity, process efficiency, or process certification work in the near term in Latin American countries with a high power distance and uncertainty avoidance. The paper postulates these are not the better predictors. The big five personality traits may be better as they are more embedded throughout life.

## **BUSINESS**

### **Western Hemispheric Issues in Trade and Management**

**Douglas Peterson**

*Westminster College*

Application of the competitive advantage of nations in Latin America projecting variance in availability of factor endowments, alignment of corporate strategy, related and supporting industries, and demand conditions are moderated by debt, culture, unstable government, and political issues with MERCOSUR and UNISUR. Implications for business

development in developing countries are assessed for managerial adaptation.

## **BUSINESS**

### **Bitcoin**

**Ron Mano & Jennifer Harrison**

*Westminster College*

Bitcoin is a hypothetical currency developed (allegedly) by Satoshi Nakamoto—however that precise identity exists. Individuals obtain bitcoin by solving complex mathematical formulas on their computers. As these become increasingly more complex, more and more bitcoins are mined. As accountants, of particular interest to these authors is the accounting for bitcoin transactions. Apparently, the Sacramento Kings of the National Basketball Association and Overstock.com, a Utah company, have begun accepting bitcoin as payment along with many other smaller establishments. The questions of how to account for the currency relates to whether it is even a currency at all. Questions exist regarding the accounting treatment of bitcoin in relationship to whether it is considered as a barter instrument or whether it can count in F(x) transactions. One other question is whether bitcoin can be counted as a marketable security. There are tremendous research possibilities involving bitcoin. Among them are proper accounting treatment, variance in exchange value, and indices that compare bitcoin with purchasing power.

## **BUSINESS**

### **Migration and population churning rates in United States counties, 2005–2010**

**L. Dwight Israelson**

*Utah State University, Indiana University*

Studies of migration typically examine migration between countries, or, in the United States, migration between states. Recently, there have been several studies done on the determinants of migration at the county level. These studies have looked at the determinants of gross in-migration, gross out-migration, net in-migration, and the migration

turnover rate. The current study extends this analysis to include the 2005–2010 period and utilizes a new concept in the migration literature: the population churning rate (PCR). The PCR is the percentage of the population of an area that moves in or out of the area during a given period of time, and is measured as the sum of gross in-migration and gross out-migration as a percentage of the population of the area at the beginning of the period. Just as laying off, replacing, and adding new employees creates costs for the employer, in-migration and out-migration creates costs for society. Hence, understanding the determinants of PCR will be useful in predicting and preparing for the associated costs. The study identifies PCRs by county for the United States for 2005–2010 and uses an econometric model to identify the importance of economic, demographic, social, environmental, and geographic variables in influencing the size of PCR.

## **EDUCATION**

### **Effects of Human Development Misconceptions on Course Achievement**

**Dana Erskine**

*Salt Lake Community College, Utah Valley University*

Research on the effect of students' prior human development misconceptions as it affects end-of-term grades in the human development classroom indicates the benefits of addressing students' prior understanding of topics of instruction. Five classes of human development were taught by the same instructor at both the community college and university level during the same term, for a total of 102 undergraduate students. All students answered pre-chapter review questionnaires referring to common human development truths and misconceptions. Results indicate a significant difference between prior accurate human development knowledge and end-of-term grades by college type and gender. Learning about the content, causes, and consequences of holding misconceptions about human development may be helpful to students and educators as they embark on a developmental psychology course.

## **EDUCATION**

### **Growing pains in Zion: Faculty governance at the University of Utah**

**Peter L. Kraus**

*University of Utah*

The lines between church and state in Utah have often been blurred more than in any other state in the Union, and church–state issues have impacted higher education several times in Utah’s history. One instance occurred in 1915 when several members of the faculty at the University of Utah did not have their contracts renewed because of unpopular remarks made by students (whom they taught and supported) at commencement. My premise is that these dismissals were motivated by political considerations and nepotism of the time not religious discrimination. I suggest that because of the lack of an organized system of faculty governance there was no real system of communication on policy matters at the University. Thus, it is likely that these actions were a result of the growing pains of the development of the University at a time when great social and economic change were occurring in the state of Utah.

## **EDUCATION**

### **A study of the Jung & Briggs Myers Personality Profile Assessment and pre-service teacher preparation in introductory education classes**

**James McCoy**

*Southern Utah University*

A teacher's personality can play a major role in classroom instruction. Do certain personalities lend themselves more to high engagement classroom instruction and interaction as identified in an introductory education class? Do certain disciplines in the school organization attract certain personalities? Are certain personalities, as identified by the Jung & Briggs Myers Personality Assessment Instrument, more likely to be attracted to the teaching profession? Is there any difference in student performance, based on their identified personality, in an introductory education class? These questions lie at the heart of research currently being conducted by Dr. Jim McCoy and Professor Ray

Brooks. The study is currently underway, and the presentation will share the initial findings and generate dialogue to further refine future research components. It is proposed that an understanding of the type and expression of personality in teacher preparation can help both the candidate and pre-service instructors prepare for success in their respective classrooms.

## EDUCATION

### **STEM persisters and switchers: The case of mathematics majors. Why do mathematics majors leave?**

**Saïd Bahi**

*Southern Utah University*

Previous studies show that only too few students enroll in STEM fields (Science, Technology, Engineering, or Mathematics). Many who initially intended to pursue a career in these fields leave sometime after their college experiences in these majors. The leakage in the mathematics pipeline constitutes an important challenge for many mathematics programs. In this study, we present results identifying determinants of students' persistence in mathematics. An individual-level data set for an entire cohort of undergraduate mathematics students at a regional public university was studied to determine the factors that influence students' decisions to switch from mathematics to a different major. Gender differences in mathematics are also investigated.

## EDUCATION

### **Engaging the school community in innovative and meaningful STEM activities**

**Prent Klag**

*Southern Utah University*

There has been much discussion in the state of Utah regarding STEM (Science, Technology, Engineering, or Mathematics) education in the public schools. In 2012, through a unique collaboration between Southern Utah University and the Iron County School District, the North

Elementary Partnership School was created. A distinctive feature of this school was the implementation of a STEM-based curriculum for all students. One of the components central to the success of the STEM curriculum was the creation of a Parent and Community Involvement Program that promotes and sponsors innovative and meaningful STEM activities. This paper provides an overview of the components of this program as well as how successful Parent and Community Involvement Programs can increase student achievement and attendance at school, promote school/community relations, build business and agency collaborations, and impact the overall success and performance of schools.

## **ENGINEERING**

### **Solar Aureole Measurements (SAM) system control**

**Connor V. George et al.**

*Utah State University*

The Solar Aureole Measurements (SAM) system is a ground-based instrumentation system that measures the optical depth of clouds and their forward scattering properties and particle size. These measurements use the sun's aureole as a light source to observe the properties of the clouds. The SAM tracks the sun across the sky to collect data for processing. The SAM control system is being developed by a team of Visidyne, Utah State University, and the Space Dynamics Lab. The control system includes setup, tracking, data logging, and maintenance software for the SAM.

## **ENGINEERING**

### **Multiple layers in SABER measurements of mesospheric O<sub>2</sub> singlet delta and OH airglow**

**Jordan Rozum et al.**

*Utah State University*

The SABER instrument aboard the TIMED satellite is a multichannel radiometer that has been continuously measuring the global altitude distribution of airglow intensity in the mesosphere since 2002. While the majority of these distributions are Gaussian-like, a significant portion exhibit two or more local maxima, suggesting multiple airglow

layers. To better understand the cause of this phenomenon, we have examined the global and temporal distribution of OH and O<sub>2</sub> singlet delta scans resulting in multiple peak profiles.

## ENGINEERING

### The volition of intelligence

**Todd K. Mood**

*Utah State University*

Computer “intelligence,” or artificial intelligence, appears to be making increasing inroads, as evidenced by computers’ increasing influence on our lives, and by successes in competitions between humans and computers. Despite these advances, computers continue in merely subservient roles, never exhibiting the ability to truly choose for themselves. In this paper, we explore this question of volition. We argue against Turing’s test as a means of showing intelligence because it fails to test for volition. Gödel’s theorem is used as an example of the result of human volition and computer’s lack of it, and we discuss the theorem in response to Hofstadter’s and Penrose’s views. We speculate on the possibility that computers may someday be capable of their own volition and contemplate the risks of the possibility.

## ENGINEERING

### Similarities between single and multi-photon X-ray diffraction spectra

**Dmitry A. Panin**

*University of Utah*

An X-ray tube detector apparatus has been utilized to investigate the differences and similarities between single- and multi-photon diffraction. Specifically, the low-intensity crystal diffraction patterns for a range of wavelengths between 50 and 150 picometers have been targeted. The purpose was to determine whether a single photon could be allowed to interact with one crystal plane at a time or if multi-plane or traditional diffraction occurs at low intensity (single-photon mode) energies as well. The results have shown that, contrary to common perception, the two modes are virtually indistinguishable. Possible

applications of such technologies to CCD image detectors are also discussed.

## **EXERCISE SCIENCE AND OUTDOOR RECREATION**

### **"Psychological momentum" in sporting events**

**M. Vinson Minder & Brock Halladay**

*Utah Valley University*

Qualitative research methods were employed to analyze and gain insight into just how elite senior athletes experience feeling of increased self-confidence and improve performance during episodes of perceived psychological momentum. Both positive and negative elements in improved cognition, heightened affect, physiological arousal, and increased conation were documented. Precipitating events, changes in performance, and independent moderating variables were also investigated. A six-point survey/questionnaire was designed and personally administered to illuminate the unique characteristics and commonalities associated with this dynamic phenomenon as it was encountered by experienced elite senior athletes.

## **EXERCISE SCIENCE AND OUTDOOR RECREATION**

### **Exercise Is Medicine: Collaboration in disease management—a new system?**

**L. Nathan Thomas**

*Salt Lake Community College*

The purpose of this application is to evaluate the practical nature of actual implementation of the Exercise is Medicine (EIM) initiative. The model tested was designed to bridge the gap between the clinical atmosphere and implementation of lifestyle intervention strategies to improve quality of life and reduce signs and symptoms of disease while collaborating across disciplines. The model uses clinical exercise physiologists and the EIM initiative as the interface between the clinicians and patient referrals.

## LETTERS—HUMANITIES, PHILOSOPHY, AND FOREIGN LANGUAGE

### **World War II female German concentration camp guards**

**Hans-Wilhelm Kelling**

*Brigham Young University*

Women were an essential and necessary part of the work force during the Second World War in Hitler's Germany. Thousands were recruited to work as guards in the infamous concentration camps and, while there, committed unspeakable crimes, matching or even surpassing those of their male SS guards. In my paper, I will discuss the background of some of these women, the duties they had to perform, and their crimes. I will also look into the typical background of these women and answer what attracted them to this kind of work. In addition, I will consider the role of female inmates themselves who were favored by their guards and became overseers of other prisoners. They also became guilty of criminal activities. Finally, I will discuss the fate of these guards after the war when allied troops had liberated the prisoners in the camps and arrested the guards. Will education be an important factor in preparing women so that in the future they will not again commit such crimes?

## LETTERS—HUMANITIES, PHILOSOPHY, AND FOREIGN LANGUAGE

### **Hollywood goes to Nuremberg: Evidentiary documentaries and the Nuremberg Trial**

**Stephen B. Armstrong**

*Dixie State University*

Following the German surrender in May 1945, the Allied powers elected to try several of the Hitler regime's surviving leaders in Nuremberg. Formally named the International Military Tribunal (IMT), the trial permitted the war's victors to dispense justice in a manner that would hopefully be perceived by international audiences as humane. But as the Allies recognized the necessity for securing convictions, the trial's prosecutors were granted unrestricted access to incriminating documents seized from the German government. In addition, documen-

tary films were commissioned that exploited footage of Nazi transgressions. While legal scholars have questioned the extent to which these films influenced the IMT judges' verdicts, their role in shaping the popular perception of Nazi culpability has been widely recognized. I plan to discuss two documentaries prosecutors screened at the IMT, "Nazi Concentration Camps" and "The Nazi Plan," and address the manner in which their creators used techniques like "invisible" cutting, balanced shot composition, and ironic narration—signature traits of pre-war popular American cinema—to enhance the emotional impact these evidentiary documentaries had upon their initial viewers.

## LETTERS—HUMANITIES, PHILOSOPHY, AND FOREIGN LANGUAGE

### **Movies, tango, gender and identity in Manuel Puig's *Boquitas pintadas* and *The Buenos Aires affair***

**Tim Robbins**

*Drury University*

Although few would question Manuel Puig's status as a canonical author today, his initial reception was rather less positive. Many critics saw Puig at best as a curiosity, largely because of the scale and scope of mass culture within his narrative. Puig represents a rejection of the current literary trends of the day and has an ambiguous place in Latin American literary criticism. He is seen as an author who jumps on the bandwagon of the Boom, or a postmodern author who uses mass culture as a way of constructing identity. What becomes evident about Puig is that while the Boom writers are creating their total novels that create self-contained worlds with a new complex aesthetic, Puig elects to express his own aesthetic innovation in the form of mass culture. In his novels, Puig uses examples of mass culture to further the argument and the psychology of his characters. This paper will show how he explores themes like identity and sexuality through the use of mass culture in both *Boquitas pintadas* and *The Buenos Aires affair*. Puig seeks to show the validity of the marginalized genres in a parallel to the discourse of gender identity and power that he explores in his novels

## **LETTERS—LANGUAGE AND LITERATURE**

### **Applying Burke's theory of identification in teaching first-year composition**

**Lacy Culpepper**

*Dixie State University*

In order for first-year composition students to appropriately compose for a particular audience, they must be aware of their presence in discourse communities. Thus, composition instructors might consider helping students better utilize Burke's theory of identification as an applicable strategy of conceptualizing the tactics of persuasion to better reach an intended discourse community.

## **LETTERS—LANGUAGE AND LITERATURE**

### **The empty laboratory: The lack of scientific apparatus and misrepresentation of experimental activities in popular science books**

**Olga A. Pilkington**

*Dixie State University*

When laboratory apparatus is described in popular science texts, it is usually in simple, everyday terms; such descriptions fail to show the communicative aspect of laboratory work and can result in misrepresentations of modern science as operating with outdated equipment and from outdated perspectives. A new literary genre of lab lit supplies a more balanced picture of science and its practices.

## LETTERS— LANGUAGE AND LITERATURE

### **“Come back from the vanished past”:The psychological perils of slavery in Charles W. Chesnutt’s “The Sheriff’s Children”**

**Randy Jasmine**

*Dixie State University*

It is not a new concept to suggest that the institution of slavery degrades all who come in contact with it—Frederick Douglass and Booker T. Washington, among many others, famously make this claim. Few writers of fiction or of history, however, are better able to graphically depict this reality than is Charles W. Chesnutt. Understanding his work is crucial to any exploration of the era leading up to the Jim Crow South.

## LETTERS— LANGUAGE AND LITERATURE

### **Heavenly objects: Stein, saints, and statues in “Four Saints in Three Acts”**

**Jennifer Large Seagrave**

*University of Utah, University of Phoenix*

Gertrude Stein’s abstract libretto to Virgil Thompson’s “Four Saints in Three Acts” (1934) echoed the cubism of Picasso and Juan Gris in two-dimensional tableaux built of words and phrases. This study analyzes Stein’s inspiration for the libretto, an interpretation of its portrayals, and its predictive use of object theory to illustrate her perception of saints as contemporary objects populating the world around us.

## PHYSICAL SCIENCES

### **ALIX is recruited temporarily at the end of HIV-1 Gag assembly**

**Pei-I Ku, Mourad Bendjennat, Jeff Ballew, Michael, B. Landesman & Saveez Saffarian**

*University of Utah*

Polymerization of Gag on the inner leaflet of the plasma membrane drives the assembly of human immunodeficiency virus 1 (HIV-1). Gag recruits components of the endosomal sorting complexes required for transport (ESCRT) to facilitate membrane fission and virion release. ESCRT assembly is initiated by recruitment of ALIX and TSG101/ESCRT-I, which bind directly to the viral Gag protein and then recruit the downstream ESCRT-III and VPS4 factors to complete the budding process. In contrast to previous models, we show that ALIX is recruited transiently at the end of Gag assembly and that most ALIX molecules are recycled into the cytosol as the virus buds, although a fraction remain within the virion. Our experiments imply that ALIX is recruited to the neck of the assembling virion and is mostly recycled after virion release.

## PHYSICAL SCIENCES

### **Effect of through-space interactions within non-classical norbornenyl carbocations on relative solvolytic reactivity using hybrid density functional theory**

**Byron Millet, Barry Lloyd, & H. Laine Berghout**

*Weber State University*

The relative solvolysis rates of norbornenyl derivatives have been of interest because of enhanced reactivity over many orders of magnitude relative to the historic anti-7-norbornene. It has been suggested that through-space interactions between adjacent  $\pi$ -bonds are the source for many of the observed enhancements. This explanation has also been disputed owing to similar enhancements for compounds without adjacent  $\pi$ -bonds. We report on our current computational study of 11 norbornenyl compounds using the Becke, three-parameter, Lee-Yang-

Parr hybrid density functional method to evaluate the effects of through-space interactions on the stability of the resulting carbocations. Our isolated-molecule calculations predict that eight of the studied compounds undergo molecular inversion of the ring structure, wherein the  $\pi$ -bonds that were adjacent in the crystal structure move away from each other, precluding the possibility of interactions through space. Molecular orbital analysis of the three non-inverting carbocations shows strong evidence for through-space interactions. The effects of these interactions correlate well with empirical solvolysis rates.

## PHYSICAL SCIENCES

### **Determining thin-film roughness with extreme ultraviolet reflection**

**Cody L. Petrie, Joshua Marx, David Squires, & R. Steven Turley**  
*Brigham Young University*

When making optics for extreme ultraviolet (EUV) applications, the optics need to be smooth at the subwavelength level. This is difficult since EUV light is on the order of 1–100 nm. To make optics more smooth, we need to be able to measure sub-wavelength roughness. Existing methods for measuring surface roughness are not sensitive enough to see small (on the order of 1–10 nm) variations in roughness. We have developed a method that utilizes the small wavelength of EUV light to measure surface roughness and have measured the roughness of UOx single-layer thin films. Roughness was also measured on the atomic force microscopy (AFM); however, the AFM results differ from those of our method. Our method may provide a more sensitive measurement of surface roughness than existing methods like AFM.

## PHYSICAL SCIENCES

### **Gold and Gallium nanoparticle growth on silicon (100)**

**J. Leland Rasmussen, Hunter L. Brown, Rees Madsen, Sadie Ames, Alexandra Ogilvie, and Samuel Tobler**

*Dixie State University*

Nanoparticles are used for various applications in today's research. Some researcher's interests involve using the nanoparticles to grow silicon nanowires on a silicon substrate. Before growing nanowires can be accomplished, a study must be made of the formation of nanoparticles. Most often, the metal used to make the nanoparticles is gold. In this study, both gold and gallium were used to make the nanoparticles, by thermal evaporation. The gold and gallium nanoparticles were grown on silicon (100). Between one and three monolayers of material were added to the substrate, with the particle sizes ranging from 0.5  $\mu\text{m}$  to 3  $\mu\text{m}$  in diameter. Densities of nanoparticles varied based on the time of growth and on the intensity of the source. The variable sizes were seen with sample temperatures between 700°C and 900°C measured using a disappearing filament optical pyrometer. The growth process occurred at pressures below  $3 \times 10^{-7}$  Torr. This presentation will summarize the growth process and show the similarities and differences between the two metals.

## PHYSICAL SCIENCES

### **Assessing the observability of the deaths of massive population III stars**

**Brandon Wiggins**

*Brigham Young University*

During the era of Cosmic Dawn at  $z \sim 20$ , it is thought that the universe was lit by giant stars, that the chemistry of the universe was fundamentally altered, and that the radiation background that would provide the scaffolding for the formation of the first galaxies was created. Unfortunately, although this period has been the subject of extensive simulation work, the first stars in the universe will not be directly observable even with the next generation of telescopes. It may be possible, however, to explore this era by observations of the luminous supernovae of Popula-

tion III stars. I will present numerical simulations of various types of primordial supernovae carried out with the Los Alamos codes RAGE and SPECTRUM. I will show that these explosions are visible out to  $z \sim 10\text{--}15$ , revealing the positions of ancient dim galaxies on the sky and tracing their star formation rates.

## PHYSICAL SCIENCES

### **Interaction of the sun's solar wind with the Venus ionosphere**

**William C. Knudsen, Douglas Jones & Bryan Peterson**

*Brigham Young University*

We report in this paper some properties of the solar wind interaction with the Venus ionosphere. We also present measurements of a high-temperature population of photo-electrons produced within the ionosphere by extreme ultraviolet and soft x-ray radiation from the sun. These results are obtained from measurements made by the ORPA instrument included in the NASA Pioneer Venus mission to measure low-temperature ionospheric quantities. Unfortunately, the solar wind plasma instrument included on the mission lacked the time resolution to provide the high spatial-resolution measurements needed. Our results, which do provide high spatial-resolution measurements, have only been obtained recently by analyzing data acquired during the mission by the ORPA instrument operating in its suprathermal electron mode. With little exception, these data were not previously analyzed during the Pioneer Venus mission.

## PHYSICAL SCIENCES

### **Newton's mechanics in multiple dimensions**

**Chin-Yah Yeh**

*Utah Valley University*

Newton's laws of motion are extended to multiple dimensions to give trajectories that obey an ordinary differential equation (ODE). We shall approach the dynamics by considering Kepler's laws, Bertrand's theorem, virial theorem, and Legendre's polynomial functions. Are Kepler's laws still valid? The solutions of ODE are classified by using

Bertrand's theorem. Virial theorem tells the stability of the solutions. Examining the hypothetical four-dimensional situation, we realize that our three-dimensional world is indeed privileged.

## PHYSICAL SCIENCES

### What is uncertain about the Heisenberg Uncertainty Relation?

**Jacob Collings & Jean-Francois Van Huele**

*Brigham Young University*

Since Heisenberg introduced the relation  $\Delta p_1 \Delta q_1 \sim \hbar$  in 1927 (*Zeitschrift für Physik*, 43, 172), great effort has been made to refine this expression and better understand its meaning. Recent work has shown that the term 'uncertainty' applies to at least two very different quantum properties. One pertains to preparation uncertainty, the principle that one cannot prepare a quantum system such that two incompatible observables are arbitrarily well-defined for it. Others pertain to measurement uncertainty, the principle that the measurement with a certain degree of accuracy of one observable disturbs the measurement of another observable incompatible with the first, be it jointly or sequentially performed with the first. We explore the fundamental differences between these uncertainties and their impact upon the Heisenberg Uncertainty Relation. We review recent experiments showing evidence for a violation of the measurement uncertainty as well as proposed reformulations of this relation. We conclude by clarifying the principles that are still debated 87 years after Heisenberg.

## PHYSICAL SCIENCES

### Measuring disembodiment or disembodying from measurement?

**Prashanna Simkhada & Jean-Francois Van Huele**

*Brigham Young University*

We use the strange case of the disembodied Quantum Cheshire Cat to illustrate the nature of measurement in the quantum world.

## PHYSICAL SCIENCES

### **Finding all three spin projections in a cone continuum using entanglement**

**Joshua Matern & Jean-Francois Van Huele**

*Brigham Young University*

Uncertainty relations constrain how much can be learned from measuring incompatible (noncommuting) quantum observables, such as different spin components. Combining entanglement with weak measurement and pre- and post-selection yields the value of all three components of spin through two measurements and inference [Phys. Rev. Lett. **58**, 14 (1987)]. Analyzing the domain of validity of this specific proposed technique enables us to extrapolate to similar proposals for the determination of any combination of incompatible observables in the quantum domain. We explore the validity of the technique for a continuum of directions that form a cone.

## PHYSICAL SCIENCES

### **Possible origin of nuclear force as GR extension of electromagnetic interaction**

**Alexander Panin**

*Utah Valley University*

Short ranginess of nuclear forces can be attributed to the existence of the event horizon for a system of charges moving with acceleration. Indeed, as quarks within nucleons (and other compound particles) orbit each other, they are seen by a distant observer as charges moving with radial acceleration. According to the equivalency of accelerated motion and gravitation, this motion may result in the emergence of a dynamic event horizon outside of the system of charges. While for slow-moving system of charges (say, electrons in atoms), the radius of this intermittent event horizon (IEH) is large compared with the wave function of the system (and thus does not influence their interaction with other system nearby); for quarks moving with relativistic velocities, the radius of the IEH becomes comparable with the wave function of their mutual orbital motion itself. This makes the interaction of one compound particle with another separated by IEH to diminish with distance not as inverse square, but as a steeper (possibly exponential) function, which

would also depend on the details of the motion of quarks within each compound particle. So, nuclear force can be the result of general relativistic limitations on the range of electromagnetic interaction for compound particles.

## POSTERS

### **Effect of inorganic salts on the aggregation of cyanine dyes in aqueous solution**

**Crystal Alamilla, Austin Reese, Yougri Jung, Donald Long, and Hussein Samha**

*Southern Utah University*

The effect of inorganic salts (lithium chloride, sodium chloride, potassium chloride, and calcium chloride) on the spectroscopy of the cyanine dyes (NK-3796 and NK-2707 whose structures are provided below) was investigated using UV-vis spectroscopy. Both dyes tend to form J-aggregates upon mixing with any of the tested monovalent cationic salts; however, H-aggregates were only observed in the case of NK-2707 upon mixing with calcium chloride (divalent cations). The appearance of a single red-shifted band at 636 nm in the UV-vis spectra suggests that the dye monomers are quantitatively converted to J-aggregate in the presence of inorganic salts. In the case of a concentrated solution of NK-2707, the J-aggregates tend to form first, then over time they convert to H-aggregates. While in diluted solution, H-aggregates are formed directly. The H-band was observed at 454 nm, and it is broad in nature.

## POSTERS

### **Exploring new means of transdermal delivery of nutrients**

**Brittany Hammontree**

*Dixie State University*

Ionic liquids are organic salts that are currently being explored in many different scientific fields because of their unique properties; however, using ionic liquids as a transporter in transdermal applications has yet

to be explored. Depending on metabolic conditions or dietary preferences, people can often become deficient in critical vitamins and minerals. For example, a number of people are deciding to become vegetarians, and vitamin B12 deficiencies could become a huge epidemic, as the essential vitamin is only obtained through meat products. This issue was the driving force to look deeper into ionic liquids and how they could be used as a transport method for vitamin B12, along with other vitamins. Developing new mechanisms of administering nutrients via transdermal processes can increase the bioavailability and effectiveness of vitamins and minerals that often cannot survive oral administering because of the acidity and molecular absorption via the stomach. One additional benefit to transdermal applications of vitamins would be the transport of these vitamins to other countries. Ionic liquids tend to increase shelf life of solutes, and the availability to provide these materials during medical missions or service trips would be increased substantially, particularly in more remote settings. This research focused on finding the right ionic liquid with high absorbance of the individual vitamins. To do this, we initially had to make several ionic liquids. After creating the ionic liquids, we mixed in our vitamin and tested the absorbance levels. This allowed us to find the maximum exposure of the vitamin during transdermal delivery. We tested two different vitamins, Vitamin K and Protoporphyrin. By testing multiple vitamins, we can see if there are similar absorptions in order to administer more than one vitamin at a time transdermally.

## POSTERS

### **Comparison of antibiotic-resistant *Enterococcus* isolates from various Weber River locations, from the Great Salt Lake, and from hospitalized patients**

**Madison Landreth, Autum Brubaker, Colton Stokes, Cody Zesiger, Alexandria Pashley, Jessica Brooke, Jhonny Yovera, Michael Harris, April Foley, Karen Nakaoka, William Lorowitz, & Mo Sondossi**

*Weber State University*

*Enterococcus* is a bacterium that normally inhabits the gastrointestinal tract of animals and can be pathogenic to humans, being an important cause of nosocomial infections. Complicating these infections is the fact that *Enterococcus* often have high levels of antibiotic resistance,

making treatment difficult. *Enterococcus* can also survive outside its hosts, even in adverse conditions such as occur in the Great Salt Lake (GSL). In this experiment, *Enterococcus* isolates were collected from the GSL, from the Weber River, and from patients. Isolates were tested for their resistance to six antibiotics. Preliminary results of the disk diffusion assay demonstrated that 9–26% of the Weber River isolates, 36% of GSL isolates, and 86% of the clinical isolates were resistant to one or more of the antibiotics; however, 40% of isolates from the end of the Weber River were resistant. These data suggest an association of human influence to rates of antibiotic resistance in *Enterococcus*.

## POSTERS

### **The Potential Excess Precipitation (PEP) Value, a New Definition**

**C. Frederick Lohrengel II**

*Southern Utah University*

When using the Köppen Climate Classification, the semiarid–humid climatic frontier is defined as occurring where potential evapotranspiration exceeds annual precipitation. Unfortunately, Köppen did not explain the definition any further. We propose a simple mathematical definition, the Potential Excess Precipitation (PEP) Value, that is defined as “actual annual precipitation minus potential evapotranspiration.” If the PEP Value is positive, the climate is Humid, A, C, or D. If the PEP Value is negative, the climate is Arid/Semiarid, BW, or BS. Using the numerical values derived from application of the formula, it is simple to contour the values and locate the semiarid–humid frontier on a map. PEP Value equal zero is the frontier location.

## POSTERS

### **Frog behavior may protect against potentially lethal chytridiomycosis**

**Hailey Shephred & Jake Lammers**

*Dixie State University*

Previous studies of canyon tree frogs (*Hyla arenicolor*) in Zion National Park have shown that some populations test positive for a dangerous fungus in the Chytridiomycosis family. This fungus has been linked to large population losses worldwide in many keystone amphibian species, but appears to have no effect on populations of *H. arenicolor*. Since Chytrid fungal growth is inhibited at high temperatures, we hypothesized the frogs are able to rid themselves of the fungus because they bask in the sun. During the summer of 2013, we swabbed frogs in multiple slot canyons to test for the presence of the fungus. We also recorded skin temperatures of the frogs we swabbed. Skin temperatures were as high as 38°C, which is above the previously established lethal threshold of 28°C for Chytridiomycosis. Our data support the idea that these frogs may be able to rid themselves of infection by allowing skin temperatures to rise enough to become intolerable for this fungus. This is the first known evidence of wild amphibian populations showing a behavior that may clear the infection. If further research supports these findings, it could lead to more effective allocation of limited conservation resources.

## SOCIAL SCIENCES

### **In the name of God**

**Shadman Bashir**

*Dixie State University*

This paper is a brief analysis of the current security situation in Pakistan and Afghanistan in the context of a holy war. The conflict is primarily cosmic in nature. The entanglement of religion and cultures within the region has created a unique social system that has blurred the lines between right and wrong, just and unjust, holy and unholy. Victory is impossible in such a conflict, which is why defeat is illogical. The conflict and related terrorism is a cocktail of religious as well as

secular doctrines. If victory is not possible, then how can defeat be avoided?

## **SOCIAL SCIENCES**

### **Undercover policing practices and challenges**

**Lindsey Bonney**

*Weber State University*

Undercover policing is a unique and complex subject for justice professionals to explore. Developing from a rich history of infamous operations and court decisions, strike force teams are operated by some of the brightest and most talented officers. By gathering valuable intelligence from surveillance and confidential informants, undercover agents are able to effectively investigate and arrest criminal offenders that would unlikely be discovered otherwise. As with any position within the justice system, however, this type of work tests one's moral character and ethical behavior. This paper will attempt to explore these moral and ethical issues. Two roles, undercover officers and confidential informants, will be examined with a detailed discussion of the many dilemmas they face. This will provide a better understanding of the practices and challenges of today's undercover police.

## **SOCIAL SCIENCES**

### **Institutionalized oppression within anti-marijuana drugs laws**

**Amy Hernandez**

*Westminster College*

Opinions surrounding current marijuana drug laws clash over abstract ideals of prohibition and morality. Yet few drug law supporters acknowledge the inherent oppression found within previous and current antimarijuana drug laws. Through analysis of the consumer types and the legislative history of the cannabis plant, institutionalized oppression becomes apparent. As this targeted oppression festers within anti-marijuana use laws, the politically elite gain more power and continue to oppress the disadvantaged. Three groups in particular suffer political disadvantage because of biased drug laws: ethnic minorities, individu-

als in the lower socioeconomic bracket, and women. Criminological theories such as conflict, the American dream, and feminist theory illustrate this power struggle inherent within drug laws. Removal of anti-marijuana laws presents a potential step forward for disenfranchised groups, but other power issues may arise upon legalizing marijuana.

## **SOCIAL SCIENCES**

### **Supply chains and song texts: An interdisciplinary study of expressive culture in East Africa's NGO sector**

**Michael Morin**

*Dixie State University*

This presentation will discuss an ongoing study that examines the impacts of a growing number of nongovernmental organizations, or NGOs, on contemporary expressive culture in East Africa. Between 2010 and 2013, 24 open-ended interviews were conducted with NGO directors, staff, and musicians who regularly participate in music initiatives in Kenya and Tanzania. A thematic content analysis of the recorded interviews, song texts from recorded concerts, film media produced by the NGOs, and promotional literature for events and organizations revealed frequent occurrences of anti-international sentiment and the promotion of "local" over "foreign" forms of cultural expression.

## **SOCIAL SCIENCES**

### **Behaviors, motivations, beliefs, and attitudes related to bottled water usage at Weber State University**

**Zackary Bjerregaard, Matthew Booth, Shannon Clugston, Miles Dittmore, Stephen Fossett, Anthony King, Dusty Pilkington, Pieter Sawatzki & Carla Koons Trentelman**

*Weber State University*

This exploratory study aims to better understand the prevalence of bottled water consumption by students, faculty, and staff at Weber State

University in Ogden, Utah, and positive and negative consequences of that consumption. In this multi-method study, we conducted a survey, receiving completed questionnaires from 711 students, faculty, and staff. Additionally, we gathered campus bottled water sales data, participated in a trash audit, researched the disposal of the plastic bottles, and investigated the demographics of brands consumed on campus to determine their environmental footprint. Twice as many of our survey respondents preferred tap water over bottled water; both groups reported convenience and cost among their top reasons. While there is evidence of some economic benefit to the university from bottled water sales, this study was unable to discover the exact amount. Our findings indicate there are more negative consequences from bottled water consumption (particularly the environmental footprint) than positive ones.

## **SOCIAL SCIENCES**

### **Planning for dark skies in the Intermountain West**

**Jeremy Bryson, Amber Corbridge & Jaisha Gull**

*Weber State University*

Light pollution increasingly threatens dark night skies throughout the cities, towns, and parks of the Intermountain West. This light pollution not only hinders human views of the stars, but it also disrupts ecosystems and represents significant waste in energy as we light the night sky. Within the last decade, communities around the Intermountain West have made efforts to curb light pollution and conserve the night sky. We argue that municipal-level planning is critical to limiting light pollution and preserving dark night skies. Through a literature review, a survey of municipal lighting ordinances, and interviews with local planners, we will explore some of the ways that communities around the Intermountain West are acting to address the negative impacts of light pollution.

## **SOCIAL SCIENCES**

### **The United States is becoming less segregated**

**L. Dwight Israelsen**

*Utah State University*

Studies on residential resegregation have concentrated on racial/ethnic segregation in neighborhoods and in standard metropolitan areas (SMAs) and have looked at socioeconomic status and other variables to explain differences in segregation measures across groups and over time. The current study examines the pattern and determinants of racial/ethnic segregation by U.S. county and state, based on census tract data for Non-Hispanic Whites, Hispanics, Blacks, Asians (Asians/Pacific Islanders), American Indians (Indians and Alaskan Natives), and All Other. The two most commonly used measures of segregation, the “isolation index” and the “dissimilarity index,” were calculated for each racial/ethnic group in each United States county for 1990, 2000, and 2010. Based on these individual indices, racial/ethnic-population-weighted segregation indices were calculated for each U.S. county for these years. In addition, county-population-weighted segregation indices were calculated for each U.S. state and for the United States as a whole. This study also utilizes a new measure of segregation, the “racial concentration ratio,” or RCR.

## **SOCIAL SCIENCES**

### **Carpooling in Northern Utah**

**Junghee Lee**

*Weber State University*

This current article reported on the willingness to accept (WTA) carpooling with binary logistic regression using the methodology of contingent valuation method (CVM). This study, a practical application of the work outlined in the previous empirical research, measured how much Weber State University students are willing to accept the introduction of car-sharing system with a detailed survey. To demonstrate the amount of WTA car-sharing, 5 different levels of compensation (\$0, \$25, \$50, \$75, and \$250) were hypothetically offered to respondents ( $n = 181$ ) enrolling for the current semester. The mean WTA was \$56.55. The marginal effect of a main interested predictor, Price, was 0.0012, meaning as one dollar increases, there is an increase in the pos-

sibility for a respondent to participate in car-sharing by 0.12%. For the improvement of the present paper, an increase in a sample size and further studies in urban areas with mass transit system may be recommended.

## **SOCIAL SCIENCES**

### **Attitudes about diversity among adjunct faculty**

**Nathan Brown, Jamie Hill, & Kerry Kennedy**

*Weber State University*

Diversity has been important topic in higher education for many years. Many different groups within higher education have been asked about opinions regarding diversity including administrators, faculty, and students. One group that often has less of a voice is adjunct faculty. Adjunct faculty at Weber State University were asked to complete a questionnaire sent out through CampusLabs. The purpose of this study was to determine the attitudes of adjunct faculty about diversity, from openness to and experience with diversity, to exploring opinions gauging Weber State University's commitment to diversity. Implications for how to improve experiences for adjunct faculty will be explored.

## **SOCIAL SCIENCES**

### **Workplace bullying: A practical guide**

**John Howell**

The problem of bullying is one that has regularly been front-page news. The subject is not new, but recently more attention has been focused on it. This paper will begin broadly with an overview of bullying, including definitions and various types of bullying. The focus of the paper will then narrow to the subject of workplace bullying, both between peers and between superiors and subordinates. The paper is intended as a practical guide to bullying and possible responses to it. Three sections will examine the responsibilities of the bully, the victim, and those close to the situation. The section on the bully will come from the perspective of a political scientist and will mainly remind the bully that in a free society the rules apply to all, even those in positions of authority. The section on the victim will draw broadly from sources in psychol-

ogy and sociology. The benefits and consequences of “whistleblowing” will also be considered. The section on those close to the situation will draw from literature on balancing self-interest with societal concerns.

## **SOCIAL SCIENCES**

### **Religious fundamentalism, sex-related guilt, and sex-related attitudes**

**Kristine J. Olson, Lacey Player, Lahela Manning, Stephanie Likos  
& Kara Anderson**

*Dixie State University*

Research has been done to establish relationships between religious fundamentalism, sexual guilt (Albertsen, O'Connor, & Berry, 2006), attitudes towards gays and lesbians (Cunningham & Melton, 2013), and the use of pornography and sex toys (Stack, 2004). The current study researched the role that sexual guilt had in relation to religiosity and attitudes towards gays and lesbians as well as the use of pornography and sex toys. A survey was distributed to a sample of 349 college students at a small university in the southwestern region of the United States. The hypothesis predicted that sexual guilt would serve as a mediator between religious fundamentalism and attitudes towards gays and lesbians, as well as mechanical devices used for sex and pornography use. Results indicated that religiosity was a key predictor in attitudes towards homosexuals and sex guilt and that sex guilt mediated attitudes about homosexuality and use of sex paraphernalia. Limitations included a sample population with a lack of ethnic and religious diversity, as well as limited ability to survey an older demographic. Future studies could include studies with more ethnic and religious diversity and research focusing on clinical therapy for sexual guilt and discrimination. The current study helps to illustrate how maladaptive sexual guilt is and how religious fundamentalists judge others by their own religious beliefs.

## **SOCIAL SCIENCES**

### **10 years of teaching Eco-psychology: why preaching to the choir matters**

**Howard Ingle**

*Salt Lake Community College*

Ten years ago, I developed a course called Eco-psychology. Since that time, the course has evolved in many ways. I would like to share my experience in developing an Eco-psychology course with other educators. The course includes a strong academic emphasis, a field school, and service learning component. It emphasizes areas of psychological study that includes Sense and Perception, Cognition, Wilderness Therapy, Personal Growth and Development. The course also focuses on concepts of Sustainability, Adaptation, and Spirituality. The paper presents longitudinal outcome data from a pre- and post-course survey on student's behavioral change while interacting with nature.

## **SOCIAL SCIENCES**

### **The colonizing of our lifeworld in the environmental claims-making arena**

**Giancarlo Panagia**

*Westminster College*

The web provides claims-makers a networking structure allowing for distribution of claims to Internet constituents. This power to make information available to the public is reflective of a trend wherein technology connects the web with communities, providing claimants with a vehicle for engaging in grassroots mobilization. Some groups maintain local chapters in areas of the country leading to a civic sphere in which adults come together to decide their response to shared problems. With the collapse of the public sphere, other groups have found it more expedient to replace a depoliticized public realm, maintaining claims-making independent of their supporters' interests. In such instance, we posit a colonization of Habermas's lifeworld is taking place. The Internet has given an advantage to groups geographically removed from local constituencies whose name is nationally recognized. What makes them successful is their type of actions. We might refer to these tactics as *armchair activism* because they do not motivate people to participate

in local demonstrations. The point is that organizing local grassroots does not appear a component in these websites. When the Internet leads environmentalists away from local protests, we should consider whether armchair activism reflects a collective association once public sphere collapses.

## **SOCIAL SCIENCES**

### **Sources of Mormon vitality in the United States: How Latter-day Saint communities function where Mormons predominate and where they are sparse**

**Rick Phillips**

*University of North Florida*

Sociologists of religion disagree about the effect of religious pluralism on religious vitality. Proponents of the "religious market" thesis argue that robust religious pluralism forces churches to compete for their members' allegiance in a crowded religious "marketplace." This competition makes churches efficient and raises mean levels of church activity. Conversely, proponents of the "secularization" thesis contend that religious groups are most vibrant where they predominate. In these settings, churches with a veritable monopoly have a nearly exclusive claim to sacred truths. This paper tests these opposing theories by examining Mormon church activity in the contemporary United States. Since Mormons predominate in Utah and are sparse throughout most of the eastern U.S., the LDS Church provides an ideal site to compare religious behavior in both high- and low-density settings. Findings show some support for both theories, and the paper concludes with suggestions for harmonizing the "religious market" and "secularization" theses.

## **SOCIAL SCIENCES**

### **The German Lebensreform Bewegung: Reacting to a continually changing world**

**Rob Reynolds**

*Weber State University*

The Lebensreform Bewegung (Life Reform Movement) is a health and beauty movement started in the 1880s. It is a predecessor of the Green movement and the health food movement, among others. This study uses social movements theory to understand its initial growth and the subsequent 100 years to understand the movement's continuing appeal, even as it faced two world wars, Nazism, a divided nation, and reunification. In the end, many of the movement's principles were mainstreamed by the larger German society.

## **SOCIAL SCIENCES**

### **Person-environment fit: Mediating personal faith and the workplace**

**Kristine J. Olson, Ann H. Huffman, Matison Snow & Brooke Budge**

*Dixie State University, Northern Utah University*

In this study, we extend previous research by examining the ability of person-organization fit (PEF) (Cable & Rue, 2002) to mediate the relationship between faith at work and positive employee outcomes that have been established by Walker (2013) (i.e., organizational commitment, job satisfaction, and turnover intentions) and outcomes that have not been previously linked to faith at work (i.e., organizational citizenship behaviors, job engagement). PEF is described as the alignment an employee perceives between his/her own values and the culture of the organization where the individual is employed (Cable & Rue, 2002). A sample of  $n = 187$  employed college students who completed an online survey at one of three universities in the United States were included in this study. The majority of participants were female (69.5%) and Caucasian (48.7%). Average participant age was 22.92 ( $SD=13.08$ ) years. The research presented in this study is an extension of Walker's (2013) research that preliminarily indicated that faith at work can contribute to positive work-related outcomes such as affective commitment.

Whereas the present research did not replicate all of Walkers' findings, the results of this study indicate that employees who integrate their faith with their job experience greater PEF, leading to positive work outcomes.

## **SOCIAL SCIENCES**

### **Social Networking Habits of Electronic Cigarette Users**

**James Bemel, Heidi McPhie, & Jamie Slade**

*Utah Valley University*

E-cigarettes are gaining in popularity, and it is important to understand how and what information is being disseminated about e-cigarettes in order to better combat misinformation. E-cigarette users completed a survey regarding their use of social networking websites. The survey inquired about participants' e-cigarette postings to each site and whether those posts portrayed e-cigarettes positively or negatively. Eighty-nine percent possessed a Facebook account, 55% possessed a Twitter account, 93% visited the YouTube site recently, and 19% possessed an account on another social networking website. Of those who posted regarding e-cigarettes, the percentage of positive posts ranged from 55% to 94%. Social media is popular among e-cigarette users, and users tend to post positive information regarding e-cigarette use. Better understanding this behavior allows professionals to more effectively prepare themselves for combating the misinformation presented as well as providing an opportunity for harnessing the power of social media.