Undergraduate Research Journal

Sabrina Bailey
Khirin Bunker
Nicole De Silva
Deanne Elliot
Shane Eum
Sarah Folk
Mira Ghabour
Amanda Haraksin
Lorraine Horwitz
Kenneth Hsu
Allison Ibarra
Zining Ji
Sanychen Muk
Clare O'Brien
Enid Ocegueda
Nicole Perez
Maria D. Ramirez Loyola
Connor Richards
Chirawat Sanpakit
Brandon Tran
Jacqueline Wong

UNIVERSITY OF CALIFORNIA
UCRIVERSIDE

University of California, Riverside
Undergraduate Research Journal

Table of Contents

From the Administration

"Congratulations to all of the authors of the Ninth Annual UCR Undergraduate Research Journal. It is a great pleasure to present the largest and most diverse journal to date, with representation from all four colleges. We value the dedication and commitment to undergraduate research and creative activity shown through the diligent work of the student authors, their faculty mentors, the Student Editorial Board and the Faculty Advisory Board."

— STUDENT EDITORIAL BOARD

Across the sciences, social sciences and humanities, the opportunity to participate in undergraduate research and creative activities can open magical new worlds for students at the University of California, Riverside.

These students have the chance to explore new concepts, investigate complex questions and advance and test their own hunches as they learn the rigor of the scientific method, the creativity of experimental design, the joy of scholarly research and personal expression, and the discipline and hard work of writing. We are proud that by the time they graduate, more than 50 percent of UC Riverside undergraduates will have participated in faculty-mentored research or creative projects.

It is a pleasure to present this year's *Undergraduate Research Journal*, which showcases the academic discoveries and creative endeavors of some of our talented undergraduates. I invite you to share the journeys they detail here. I know you will be inspired, as I am, by the quality of the work they have achieved.

Kim A. Wilcox
Chancellor

You hold in your hands the Ninth Annual *UC Riverside Undergraduate Research Journal*. It provides a selective, peer-reviewed venue featuring the very best faculty-mentored undergraduate research and scholarship on our campus. The peer-review process has been very ably led by our Student Editorial Board, with advice as needed from the Faculty Advisory Board. I would like to thank Gladis Herrera-Berkowitz, Director of Student Success Programs, for able and timely organizational work that helped to bring this inspiring journal to fruition. Thanks also to Sheena Thrush, who assisted in this work.

I want to congratulate the young scholars whose work appears here in. The process of discovery can be filled with excitement but also with frustration, as we search for the golden threads that tie together the ideas we have been pursuing and the findings that have emerged from our work. During this process, we travel a path that no one has been on before. The journal article is the culmination of that process—a formal presentation to our community of peers and mentors of what we found on that journey. Place this volume on your bookshelf. Pull it down occasionally from the shelf to re-read and to remind yourself of the journey you traveled. I wish you many more such journeys in the future.

Best regards,

Steven G. Brint
Vice Provost for Undergraduate Education
Professor of Sociology

UCR Undergraduate Research Journal

Student Editorial Board

Editor-In-Chief:
Julianne Rolf
Environmental
Engineering

Associate Editor:
Ivan Copado
Creative Writing

Associate Editor:
Krystal Vasquez
Chemistry

Members:

Mayra Cortez	Bioengineering
Michael Deo	Bioengineering
Vi-Khoi Duong	Cell, Molecular, and Developmental Biology
Bianca Freeman	Political Science, Middle East and Islamic Studies
Lauren Green	Anthropology
Joel Herrera	Sociology and Latin American Studies
Andrew Holyfield	Creative Writing
Francisco Ilabaca	Economics
Melissa Mikail	Philosophy/Law and Society
Nicole Perez	Psychology
Geoffrey Pronovost	Biochemistry
Boi Quach	Bioengineering
Claire Tran	Bioengineering

Ad Hoc SEB Members

Sarah Allec	Mathematics
Jessica Baker	History
Alexis Dennis	English
Marcelo Guardado	English
Colette King	English
Gloria Kyallo	Political Science/International Affairs
Shirley Leanos	Political Science
Anagha Madgulkar	English
Mary Michael	Sociology/Law and Society
Kris Moisa	Political Science/International Affairs
Keely Smith	Languages and Literatures/Languages

Editorial Team:

Gladis Herrera-Berkowitz	Director of Student Success Programs, Undergraduate Education
Nancy Kameya	Program Assistant, Student Success Programs, Undergraduate Education
Sheena Thrush	Program Assistant, Student Success Programs, Undergraduate Education
Christine Victorino	Assistant Vice Provost, Undergraduate Education
Tim Watson	Writing Support Specialist, Academic Resource Center

Faculty Advisory Board

Dimitrios Morikis	Bioengineering (Chair)
Curt Burgess	Psychology
Monica Carson	Biomedical Sciences
Andrea Denny-Brown	English
William Grover	Bioengineering
George Haggerty	English
Morris Maduro	Biology (On sabbatical leave)
Ilhem Messaoudi	Biomedical Sciences
Len Mueller	Chemistry
Carolyn Murray	Psychology
Vorris Nunley	English
Robert Parker	Sociology
Marko Princevac	Mechanical Engineering
Rebekah Richert	Psychology
Conrad Rudolph	History of Art
Wendy Saltzman	Biology
Dana Simmons	History
Katharine Sweeny	Psychology
Georgia Warnke	Political Science

Executive Committee for Undergraduate Research

Steven Brint, Vice Provost for Undergraduate Education, Committee Chair

Peter Graham, Associate Dean, College of Humanities, Arts and Social Sciences

Kazi Mamun, Assistant Dean, School of Business Administration

Michael McKibben, Divisional Dean, College of Natural and Agricultural Sciences

Chinya Ravishankar, Associate Dean, Bourns College of Engineering

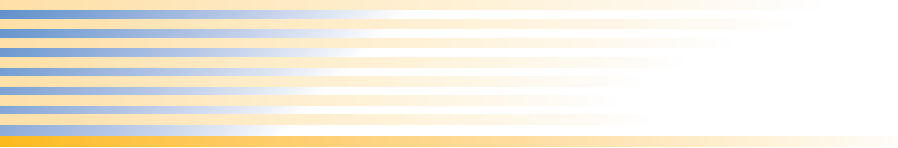***UCR Undergraduate Research Journal* Student Editorial Board:**
Back Row (left to right)**: Geoffrey Pronovost, Michael Deo, Andrew Holyfield, Boi Quach, Vi-Khoi Duong, Ivan Copado, Francisco Ilabaca**
Front Row (left to right)**: Lauren Green, Nicole Perez, Bianca Freeman, Mayra Cortez, Claire Tran, Julianne Rolf, Melissa Mikail**
Not pictured: **Joel Herrera, Krystal Vasquez**

Controlled Synthesis for Silver Nanowires for Plasmonic Nanofocusing Probe

Sabrina Bailey, Sanggon Kim, Rouxue Yan

Department of Chemical and Environmental Engineering

ABSTRACT

Active size control in silver nanowire (AgNW) synthesis is pivotal for the optimization of Plasmonic Nanofocusing Near-field Scanning Microscopy (PN-NSOM) tips, in which AgNW is the key component. Previous reports on the controlled growth of AgNW primarily focus on the growth conditions instead of nucleation conditions. We have shown, however, the nucleation temperature plays a major role in the diameter control of AgNWs. The samples were characterized using the scanning electron microscope (SEM) and UV-visible spectroscopy (UV-Vis) to determine the NW size of each sample. The results show a correlation between the seeding temperature and the final diameter of the NWs. As the temperature decreases, the nuclei formation happen at a slower rate; therefore, decreasing the size of the wire. With the diameter-controlled synthesis, we were able to examine the dependence of the optical transmission of the PN-NSOM probe on AgNW diameter, in the range of 70-180 nm. We have demonstrated a 10 fold dependence of the optical transmission of the PN-NSOM tip on NW diameter, and a 10^5 improvement in transmission compared with conventional NSOM probe. This would greatly improve the contrast and image construction speed of NSOM and allow the wide application of this high resolution technique in nano- and bio-imaging.

Keywords: Silver Nanowire, Nucleation, Nanowire size control, Surface plasmon, Diffraction limit, Near-field Scanning Microscopy

FACULTY MENTOR

Ruoxue Yan

Department of Chemical and Environmental Engineering

Dr. Ruoxue Yan is an Assistant Professor in the Department of Chemical and Environmental Engineering. Dr. Yan received her Ph.D. degree from UC Berkeley in 2010, with her doctoral research focusing on design, synthesis and fabrication of nano-materials for photonic applications, and she did her postdoc research in Laurence Berkeley National Lab. Her current research interests lies in synthesis, characterization and device implementation of advanced nanophotonic materials, with an emphasis on nanowire-live cell interface, high-resolution optical imaging and nanoscale 3D printing.

AUTHOR

Sabrina Bailey

Department of Chemical and Environmental Engineering

Sabrina Bailey is a senior majoring in Chemical Engineering. She has been working in Dr. Ruoxue Yan's lab since March 2014 focusing in nano material synthesis. Sabrina has become very passionate about learning and conducting the research in which she has been participating. It has become her goal to share the impact nano material synthesis has on new technology by publishing a paper in a science journal. Sabrina has received the HSI Undergraduate Research fellowship for 3 quarters and was part of the Material Connection Research Experience (MacREU) in the summer of 2014, which funded her research.

Sabrina Bailey

INTRODUCTION

Near-field scanning optical microscopy (NSOM) is an ultrahigh resolution optical imaging technique. By detecting and utilizing the near-field light before it undergoes diffraction, NSOM retains the full gamut of contrast mechanisms afforded by optical microscopy methods for optical, chemical, and structural characterization; while attaining spatial resolution far beyond the classical optical diffraction limit (~500 nm). However, conventional NSOM probes suffer from either extremely low optical transmission (~10^{-6}), or low signal-to-noise ratio; both of which significantly limit the speed of image construction[1]. We have proposed a plasmonic nanofocusing NSOM probe (PN-NSOM) based on metal nanowire (NW) waveguides as shown in Figure 1. Both high signal contrast, and strong signal intensity, has been achieved by adiabatically coupling light from a tapered optical fiber to a metallic NW waveguide; with efficient light coupling.
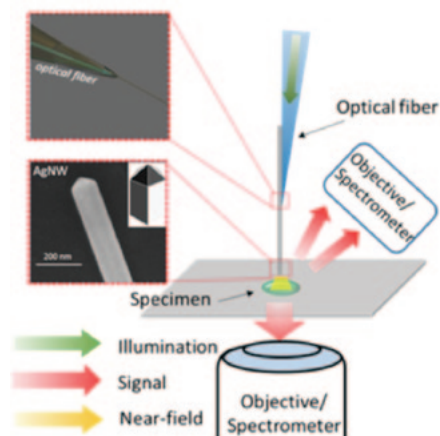
Figure 1. *A schematic illumination of the PN-NSOM. Light is coupled to the AgNW from the tapered optical fiber and majority of the light is emitted at the sharp tip of the AgNW. Near-field light can be exploited by placing the tip of the NW closely to the sample. Small illumination volume can be achieved due to the sharp tip of the NW; which leads to high spatial resolution.*

The metallic NW of our device can deliver much shorter wavelengths via surface plasmon polaritons (SPPs), or propagating electron density waves; which are not under the dictation of the diffraction limit like their dielectric counterparts[3]. However, propagation loss in metallic NWs arises from joule heating since the SPPs are excited by coupling the electromagnetic wave to surface collective oscillations of free electrons in a metal[2]. There is usually a large propagation loss in the PN-NSOM[4]. Therefore, to overcome this issue, silver (Ag), which has the lowest intrinsic ohmic loss of all metals in the visible frequency range, is the natural material choice for the probe. AgNW synthesized via polyol-mediated reduction can further limit the scattering loss from grain boundaries, structural defects and surface roughness[3]. These AgNWs have been demonstrated to have a more remarkably lower propagation loss than their lithographically defined counterparts[4]. Such low ohmic loss arises from (1) the single crystalline nature, (2) chemical homogeneity or low impurity level, and (3) atomically smooth surfaces. All of these mentioned factors effectively reduce the electron scattering during the collective electron oscillations in the plasmonic waveguide. Another merit of the AgNW as a NSOM probe is its sharp tip; where energy (carried as SPs) is released into free space. Due to the sharp tip, the illumination volume is so small that significantly high spatial resolution can be achieved with the probe.

To be effective and minimize unwanted illumination at the junction between NW and optical fiber, it is necessary to maximize the total transmission. There are many parameters that influence the total transmission of PN-NSOM; such as taper angle, wavelengths, overlapping lengths, and NW diameter. The first step for analyzing the influence of the NW diameter on the total transmission is to synthesize different diameters of AgNW. It is a commonly accepted idea that the nuclei size of Ag determines the size of the Ag seeds. The diameters of AgNWs have little variation from the size of Ag seeds in the following growth process[5]. Therefore, controlling the nuclei size is a critical parameter for the AgNW size control. It has been reported that small nanoparticles can be formed at a low temperature (T=39°C)[6]. Therefore, we can assume that the nucleation of Ag would occur at a lower temperature than the formation of the nanoparticles. Although, the nucleation is an important factor for the size control of the NW, most of the NW size control was conducted by changing the molar ratio of the reactants[3], the NW growth temperature[7], or by adding different control agents[8]. All the methods to control the size of the NWs were conducted

during the growth reaction, not in the precursor state where nuclei are already formed.

In this paper, we propose a new way to control the thickness of NWs via controlling the storage temperature of the reactants before it is injected to the growth solution; to control the nuclei size. The AgNW diameter was analyzed with the SEM and the UV-Vis. Finally, the dependency of the NW diameter on the total transmission in our device was analyzed by measuring the intensity of the light at the tip of the NW.

EXPERIMENTAL

Materials

AgNO$_3$ (99+%), PVP powder (avg Mw # 55 000), CuCl$_2$·2H$_2$O (99.999+%), Cu(NO$_3$)$_2$ ·2.5H$_2$O (99.999%), and CuCl (99.995+%) were all purchased from Aldrich. Ethylene glycol (99%) was purchased from J.T. Baker.

Procedure

For our experiment, 5 mL of ethylene glycol (EG) was inserted into an oval flask with a stir bar. The flask was then immersed in a silicon oil bath at 152 °C, and heated for 15 mins under magnetic stirring at 400 rpm. While this was occurring, the precursor solutions were being prepared. Then, AgNO$_3$ dissolved in EG was stored at different temperatures (0 ~ 60 °C). Ice baths were used for 0 °C, while an oven was used for the high temperature. After EG was heated, CuCl$_2$ was added and allowed to heat up for an additional 15 mins. Finally, 1.5 mL of a 0.147 M PVP solution in EG was added into the heated EG, along with 1.5 mL of a 0.094 M AgNO$_3$ solution in EG[7]. Certain color changes are observed when syntheses produce a high-yield of AgNW: at first it is clear and colorless, to yellow within 1 min, to red-orange within 3 mins, and then to a grey creamy color with a silver swirl within 30 mins. We stopped the reaction upon the NW formation by removing the flask from the silicon oil bath and letting it cool. After cooling, the products were washed once with ethanol and purified by centrifugation at 4000 RPM for 40 mins at least 5 times to remove all impurities. Light intensity was measured to study the dependency of our PN-NSOM probe performance on the NW diameter.

First, the single mode optical fiber was chemically tapered. To couple the AgNW to the tapered optical fiber, AgNWs were drop-casted on a polydimethylsiloxane film. Using a manipulator, AgNWs with different diameters were picked up and placed at the tip of the tapered optical fiber. 532 nm wavelength light from a laser diode module was coupled into one of the end of the optical fiber and guided to the other end of the optical fiber and the AgNW tip. The light intensity at the tip of the AgNW was measured using a CMOS camera (Zyla 5.5, Andor, Belfast, UK).

Results

The facets of the AgNW are composed of {111} and {100}. Here, the enclosed is the index of the crystal plane and the braces represents the set of the parallel crystal planes. The role of each precursor solutions in a polyol synthesis of AgNW is shown in Figure 2. Polyvinylpyrrolindone (PVP) is used to cover the {100} facets to allow Ag atoms to attach on the {111} facets and grow vertically instead of horizontally. However, oxygen can absorb and dissociate on the {111} facet not allowing the Ag atoms to attach. Thus, oxygen needs to be eliminated from the environment. Here, CuCl$_2$ was used to eliminate the absorbed oxygen. Copper(II) can be reduced by EG to copper(I), which gets any absorbed oxygen on the facets; therefore helps the growth of the wires. The chlorine also is important because it acts as a complex agent and creates AgCl. This allows a slow release of the Ag atoms which leads to a more stable growth of the wires[9].
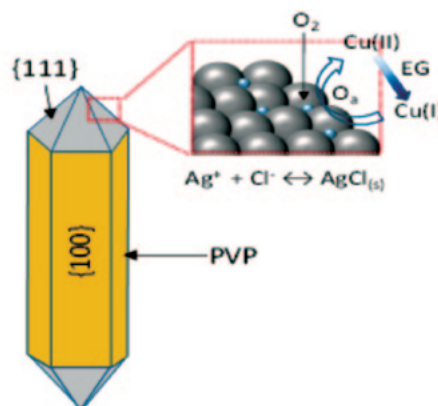

Figure 2. *A schematic that shows the role of each precursor solutions to create the AgNW. PVP covers the {100} facet allowing the growth of the NW to happen along a vertical direction. Addition of CuCl$_2$ removes the O$_2$ atoms attached to the NW; as well as lowering the reduction rate of the Ag ion[6].*

After purifying different samples of the NWs via centrifugation, the diameter size was checked with SEM. The diameter of NWs depends on the storage temperature of the $AgNO_3$ in EG before the injection to the reactor, as shown in Figure 3. In figure 3 a-b the precursor solutions are both in ice baths. However, 3a was in an ice bath for 30 mins, while 3b only 10 mins, resulting in a thinner wire. The precursor in figure 3c was left alone at room temperature, while the precursor for figure 3d was put in an oven at 60°C.

The SEM is a great tool for discovering the size of NWs in a localized area, so the UV-Vis was used to check the entire batch of the synthesized NWs shown in Figure 4. In literature, it has been noted that AgNW have their main surface plasmon resonance (SPR) peaks appear at 350 and 380 nm[10]. These two peaks correspond to the transversal plasma modes of the AgNW. The weaker peak at 350 nm is ascribed to the quadrupole resonance; and the stronger peak at 380 nm to the dipole resonance modes. As the diameter increases, the strong peak shifts to a larger wavelength and broadens. The shift and broadening of the width of the peak is attributed by the change of the cross section of the NWs from pentagonal to polygonal with increasing the NW diameter. The symmetry of the NWs is increased as the cross section of the NWs become polygonal which leads to the decrease in the number of the surface plasmon peaks[5,8,11].
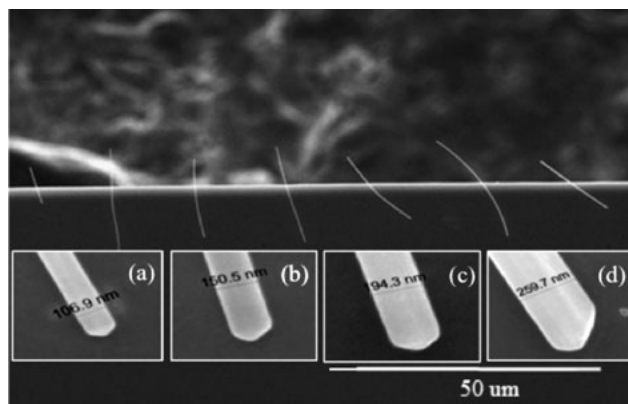
Figure 3. *SEM images of different sized NW placed on a silicon substrate. (a) $AgNO_3$ precursor solution in an ice bath for 30 mins. (b) $AgNO_3$ precursor solution in an ice bath for 10 mins. (c) $AgNO_3$ precursor solution at room temperature. (d) $AgNO_3$ precursor solution in an oven[7] at 60°C.*

The initial temperature of the $AgNO_3$ precursor solution plays a critical role in the diameter of the NWs. The amount of nuclei formed is related to Gibb's free energy by the equation:

$$\Delta G = \Delta\mu_v + \Delta\mu_s = \left(\tfrac{4}{3}\right)\pi r^3 \Delta G_v + 4\pi r^2 \gamma \qquad (1)$$

where ΔG is the total free energy, $\Delta\mu_v$ is the change of volume free energy, $\Delta\mu_s$ is the surface
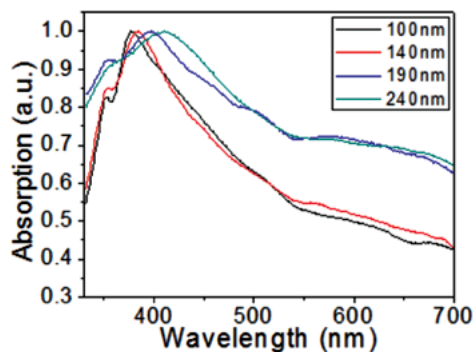
Figure 4. *UV-Vis absorption spectra of silver nanowires with different diameters: 100 nm, 140 nm, 190 nm, 240 nm. The strong absorption peak at around 380 nm shifts to a larger wavelength and broadens, as the diameter increases.*

free energy[12]. $\Delta\mu_v$ can be described as the volume multiplied by G_v, the change of gibbs free energy per unit volume of the solid phase. G_v is dependent on the concentration of the solute. When G_v is negative, nucleation happens spontaneously. Lastly, $\Delta\mu_s$ can be described as the surface area multiplied by γ, the surface energy per unit area. Temperature increase causes G_v to become more negative due to the change in G_v being proportional to the temperature. Because of this, as temperature is increased, more nucleation occurs spontaneously. As time goes by, these Ag nuclei agglomerate together creating larger nuclei, shown in figure 5b. So in the precursor solution, nucleation begins, 5a, which determines the diameter size of the wires; the bigger the nucleation particles, the larger the diameter; 5c. Decreasing the temperature of the precursor solution via ice bath allows smaller nucleation particles which create thinner, or smaller diameter wires, 5d. Therefore, increasing the temperature of the precursor solution in an oven creates thicker or larger diameter wires.

Experimental investigation on the dependence of NW diameters on the total transmission was conducted; as
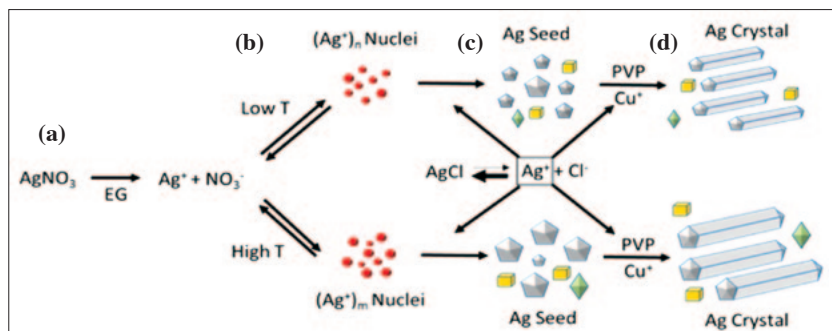
Figure 5. A schematic illustration depicting the mechanism of AgNW synthesis by controlling the initial temperature of the reactant. Depending on the nucleation temperature, different sized nuclei will be formed from the Ag ion in EG. These different sized nuclei will result in different sized Ag seeds and eventually Ag crystals.

shown in Figure 6. The experimental results showed that the total transmission is significantly affected by the NW diameter. Strong light emission intensity at the tip of the NW was observed with a thick NW diameter. This result is because the AgNWs with a larger diameter has a lower resistance due to the larger cross sectional area. Moreover, since most of the propagating electromagnetic fields exists interface between the metal and dielectric material, smaller surface area results in a larger electric distribution in the AgNW; which results in a larger ohmic loss.
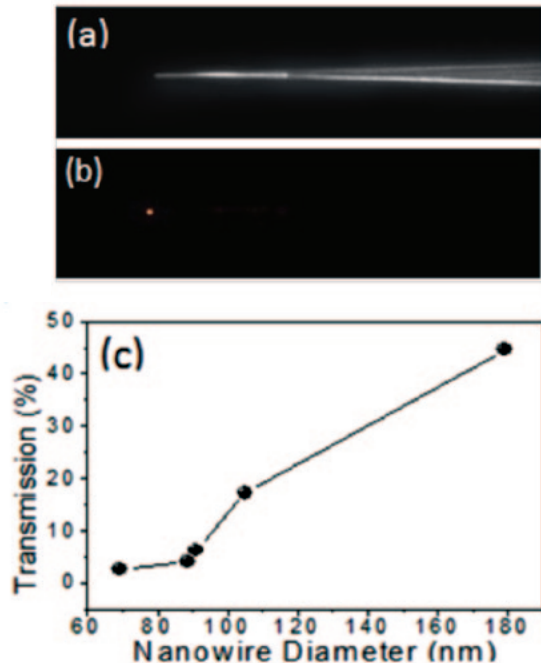
Figure 6. Total transmission of the PN-NSOM probe. (a-b) Dark-field optical images of AgNW couples to a tapered optical fiber under the microscope illumination and without the illumination. (c) Dependence of light emission intensity at the tip of the NW on NW diameters.

45% of the total transmission could be achieved with NWs in 180 nm diameter respectively. Compared with commercial aperture probes, PN-NSOM probe has 6 orders of magnitude higher transmission (10^{-6} vs. 45%). This means NW probes have much stronger signals, and therefore much shorter collection time/spectra.

CONCLUSION

 In conclusion, we have shown the feasibility to control the diameter of AgNWs by varying the seeding temperature of Ag prior to the injection of these seeds into the growth solution. We have observed a consistent decrease in AgNW diameters as seeding temperature drops from 60 °C to 0 °C, as shown from SEM and UV-Vis spectra. This new technique revealed the importance of the nucleation temperature on the AgNW formation and growth. Using AgNWs prepared by this technique, we were able to examine the effect of AgNW diameter on the total transmission of the PN-NSOM probe, which is fabricated by optically coupling an AgNW to a tapered optical fiber tip. We have confirmed a positive dependence of the probe transmission on the AgNW diameter in the range of 70-180 nm, and demonstrated a 10^5 improvement in transmission compared with conventional NSOM probe. Such high transmission will result in large improvement in the imaging contrast and scanning speed and will allow for wide application of the PN-NSOM probe for material/device characterizations and biological imaging.

ACKNOWLEDGEMENTS

REFERENCE

1   Hecht, B. *et al.* Scanning near-field optical microscopy with aperture probes: Fundamentals and applications. *The Journal of Chemical Physics* **112**, 7761-7774, doi:doi:http://dx.doi.org/10.1063/1.481382 (2000).

2   Maier, S. A. *Plasmonics: fundamentals and applications: fundamentals and applications*. (Springer Science & Business Media, 2007).

3   Coskun, S., Aksoy, B. & Unalan, H. E. Polyol Synthesis of Silver Nanowires: An Extensive Parametric Study. *Cryst Growth Des* **11**, 4963-4969, doi:10.1021/cg200874g (2011).

4   Yan, R., Pausauskie, P., Huang, J. & Yang, P. Direct photonic–plasmonic coupling and routing in single nanowires. *Proceedings of the National Academy of Sciences* **106**, 21045-21050 (2009).

5   Ran, Y., He, W., Wang, K., Ji, S. & Ye, C. A one-step route to Ag nanowires with a diameter below 40 nm and an aspect ratio above 1000. *Chem Commun* **50**, 14877-14880 (2014).

6   Silvert, P.-Y., Herrera-Urbina, R. & Tekaia-Elhsissen, K. Preparation of colloidal silver dispersions by the polyol process. *J Mater Chem* **7**, 293-299, doi:10.1039/A605347E (1997).

7   Bergin, S. M. *et al.* The effect of nanowire length and diameter on the properties of transparent, conducting nanowire films. *Nanoscale* **4**, 1996-2004 (2012).

8   Chen, C. *et al.* Study on the synthesis of silver nanowires with adjustable diameters through the polyol process. *Nanotechnology* **17**, 3933 (2006).

9   Korte, K. E., Skrabalak, S. E. & Xia, Y. Rapid synthesis of silver nanowires through a CuCl- or CuCl2-mediated polyol process. *J Mater Chem* **18**, 437-441, doi:10.1039/B714072J (2008).

10 Wiley, B. J. *et al.* Maneuvering the Surface Plasmon Resonance of Silver Nanostructures through Shape-Controlled Synthesis. *The Journal of Physical Chemistry B* **110**, 15666-15675, doi:10.1021/jp0608628 (2006).

11 Chen, D., Qiao, X. & Chen, J. Morphology-controlled synthesis of silver nanostructures via a solvothermal method. *J Mater Sci: Mater Electron* **22**, 1335-1339, doi:10.1007/s10854-011-0309-x (2011).

12 Cao, G. & Wang, Y. *Nanostructures and Nanomaterials: Synthesis, Properties, and Applications*. (World Scientific, 2011).

Old and New Governmental-Criminal Relationships in Mexico

Khirin Bunker, David Pion-Berlin

Department of Political Science

ABSTRACT

In the 21st century, there has been an apparent shift in the operations of Mexican criminal organizations since the onset of democratization. The growing influence and unchecked violence carried out by these groups has had a major impact on state sovereignty. The larger work entitled "Old and New Governmental-Criminal Relationships in Mexico: A Historical Analysis of the Illicit Political Economy and Effects on State Sovereignty," which was submitted for graduation with University Honors (Winter 2015), explores in depth the transformation of the governmental-criminal relationship in Mexico through a historical analysis of the illicit political economy. This article will briefly summarize the concept of old and new model governmental-criminal relationships introduced in the larger work.

Keywords: cartels; illicit economy; Mexico; models; narcos; trafficking.

FACULTY MENTOR

David Pion-Berlin

Department of Political Science

David Pion-Berlin is a Professor of Political Science at the University of California, Riverside. He is a Latin Americanist widely known for his research and writings on civil-military relations, security, and human rights. He is the author or editor of seven books and several dozen articles and chapters. His articles have appeared in such journals as *Comparative Politics, Comparative Political Studies, Armed Forces & Society*, and *The Latin American Research Review*. He is a Fulbright Scholar and the recipient of numerous other grants and fellowships.

AUTHOR

Khirin Bunker

Department of Political Science

Khirin Bunker is a University Honors student who recently graduated with a B.A. in Political Science. He completed his Honors Capstone Project in Winter 2015, under the mentorship of Professor David S. Pion-Berlin. During his time at the University of California, Riverside, he was inducted into the Pi Sigma Alpha and Phi Beta Kappa honor societies. He was also a co-founder of The Political Science Society at UCR. Following commencement in the spring, Khirin aims to pursue a Juris Doctorate.

Khirin Bunker

In Mexico, drug trafficking has perennially existed as a component of the informal economy. Under the Partido Revolucionario Institucional (PRI), or Institutional Revolutionary Party, which governed the country for 71 years, criminal groups were permitted to operate as long as they remained within the boundaries of PRI control. During the 20th century, a level of cooperation between criminal organizations and the state was maintained under the PRI. Through national profit-taking, the illicit economy was contained. Homogeneity allowed the state to enforce policies and coordinate action effectively throughout federal, state, and municipal agencies. With coercive power in the hands of the state, the economic value of drug trafficking was held in check and drugs were kept largely exterior to domestic markets. In this sense, criminal elements were subordinate to the state. Though violence existed, it was historically tolerated to the extent that it remained confined and out of the headlines. The stability brought about by state-backing in this arrangement was largely responsible for a low level of militarization despite high levels of corruption.

The election of Vincente Fox from the National Action Party (PAN) in 2000 was consequently viewed as a revolutionary upset. Though the change in political authority had threatened the position of the drug traffickers in the previous century, it quickly proved to be of major benefit. The new existence of political opposition, while seen by international champions of democracy (including the United States) as a step in the right direction, had significant impacts on Mexican state capacity. With the presence of political partisanship came legislative gridlock. Additionally, the historical dominance of the PRI made members highly reluctant to cooperate with the political newcomers. This divide meant, at a minimum, that the government was crippled to enact policies against the cartels and, at worst, rendered the government non-functioning as evidenced by the fact that party disputes even "led to armed standoffs—not with drug dealers but between federal, state, and local police forces, such as the one that occurred in Tijuana in 2005."[1] With this partisan discord in effect, the narcos had a window of opportunity. As per Shannon O'Neil, soon "drug-trafficking organizations took advantage of the political opening to gain autonomy, ending their subordination to the government."[2]

When Felipe Calderón took presidential office in December of 2006, the nature of the relationship between the government and drug trafficking organizations was already drastically different from that of the previous century. In the case of the PRI regime, corruption throughout all levels of government had sustained a party-wide system of control over drug trafficking organizations via an institutionalized structure of tacit rules. This system allowed for the PRI to control and contain, to an extent, the operational capacity of individuals and/or organizations in the illicit economy. Towards the end of the century, however, this control was crippled through radical governmental transformation starting in the mid-1990s under President Zedillo. The changing political landscape that had begun with Zedillo's reforms and created conditions for the presidency of Vincente Fox thus formed a paradox: more political freedom ultimately resulted in weakened state capacity. Under Fox, new efforts targeting governmental corruption—which can be seen through reforms such as the immediate creation of the Comisión Intersecretarial para la Transparencia y el Combate a la Corrupción (CITCC)—further destabilized informal governmental regulatory practices. A democratization of government and increasing public acknowledgement of corruption under Fox, while seemingly progressive towards democratic ideals, was detrimental to governmental hegemony. It has been said that "the growth of drug organizations in concert with the weakening of the state had significantly enhanced the ability of the former to capture state agencies and personnel through massive payoffs."[3]

With narcos attempting to maintain political footholds in the midst of rapid governmental overhaul, the relationships between federal, state, and municipal government were further complicated. The vertical integration of the illicit economy and profiteering under the PRI's autocratic rule had given way to a fragmentation of political power along vertical and horizontal lines; at the same time, inter-agency conflict due to party rivalry was exacerbated by divisions created through corruption among personnel at all levels. To borrow from John Bailey, the complex political discordance during this period of democratization can be attributed to "competitive state-making" practices involving "the struggle by state and civil society actors attempting to foster formal legality against de facto powers

acting to avoid or bend the law to their interests."[4] Acting as a de facto power, the more powerful drug trafficking organizations—which will be discussed later—worked to shape emergent democracy in their favor as much as other politically influential organizations.

The transition from an old model of collaboration to a new model of competition between government and drug trafficking organizations was therefore indicated by the shift in protocol under the Fox administration. In these formative years, the epochal transition was evidenced in both widespread governmental instability and an increase in cartel violence. The six years of Fox's regime can, in this way, be viewed as a period of transition characterized by strategic repositioning on both sides of the law. However, the declaration of war on the cartels by President Calderón in 2006 can be seen as the critical moment in rapidly transforming the political modus operandi. In 2005, Fox had begun the escalation of federal intervention by directing 1,500 army soldiers and federal police into Nuevo Laredo.[5] In contrast, Calderón deployed more than 27,000 federal police and army personnel to eight states within the first three months of his administration.[6] Calderón's implementation of the "kingpin strategy" further contributed to this dynamic shift.

Conceived in the 1990s by the DEA and employed against Colombian traffickers, the kingpin strategy was designed to cripple and take apart the largest drug trafficking organizations. Through organized targeting of vulnerabilities—such as finances, communications, transportation, and leadership structure—the DEA aimed to systematically attack and destroy organizations such as the Medellín Cartel.[7] The replication of the strategy by Calderón's administration led to numerous arrests of high-ranking members of the major cartels. By 2012, the administration stated that it had taken out two-thirds of Mexico's 37 most wanted criminals employing kingpin tactics.[8] Despite these statistics, Calderón's six-year militarization of governmental operations against the cartels had major repercussions. One such consequence was a massive spike in the level of violence linked to the narcos due to increased pressure and instability. Between 2007 and 2012, the rate of killings increased steadily, "averaging 56 people per day" which was "double the daily average

during the previous term of Vicente Fox."[9] By the end of six and a half years, "at least 130,000 Mexicans [had] been murdered and another 27,000 [had] officially disappeared".[10]

When Enrique Peña Nieto came to office in December 2012, he had maintained a platform that proposed an alternative to the warlike approach of Calderón. His security strategy was constructed around the premise of forming a gendarmerie (paramilitary force). Theoretically, this group would be composed of around 40,000 former soldiers with the objective of removing the military from policing operations by creating a competent alternative force. However, the actuality of its operationalization in recent years has proven to be underwhelming. Less than a year after Peña Nieto's inauguration, the number of proposed forces shrunk drastically from 40,000 to 5,000 and their promised autonomy was replaced with the planned incorporation of the force under the federal police.[11] The force did not operationalize until September of last year.[12]

In what seems to be an effort to circumvent security headlines, the Peña Nieto administration has appeared reticent to bring issues pertaining to corruption or the drug trafficking organizations into national/international rhetoric. As expressed in an *Economist* article last November, "on paper, Mr. Peña has a grand crime-prevention strategy [however] his real efforts have been focused on the economy."[13] While some have cited gradually dropping murder rates as a sign of improvement, the fact remains that the Peña Nieto administration has seen an increase in both kidnappings and extortion.[14] Although the current government has been largely successful in muting the security problems in the media realm, the kidnapping and murder of 43 student teachers in Iguala last year is but one indication of the reality of the present situation.[15]

In examining these realities and the fundamental changes accompanying them, the new model of Mexican drug trafficking organizations decentralization and diversification can begin to be understood. When Calderón took office in December 2006, the four major drug trafficking organizations in Mexico considered to be the most powerful were the Tijuana/Arellano Felix

organization (AFO), the Sinaloa cartel, the Juárez/Vicente Carillo Fuentes organization (CFO), and the Gulf cartel.[16] At the time, these drug trafficking organizations appeared to have established secure footholds in their respective regions, having endured the initial phases and messy progression towards democratization. Through the pressures spawned by Calderón's new wave of reforms, and subsequent struggles for power amongst the principal cartels, the dominance of these organizations was short-lived. Within several years, the U.S. Drug Enforcement Administration (DEA) began to recognize that there were then seven primary organizations: including Sinaloa, Los Zetas, Tijuana/AFO, Juárez/CFO, Beltrán Leyva, Gulf, and La Familia Michoacana.[17]

By the end of Calderón's administration, the involvement of federal forces and increase in violence among drug trafficking organizations had contributed to a continued fracturing of these organizations and an increase in diversification of criminal enterprises (which will be visited in the next section). At the time, the number of drug trafficking organizations had become indeterminate. Following the end of the Calderón's administration in December 2012, Attorney General Jesús Murillo Karam estimated that there were "between 60 and 80 [groups]" operating throughout Mexico, including smaller and medium tier gangs.[18] While this number was arguably higher than most estimates at the time, it serves a purpose in illustrating the mounting complexity of the situation.

Though the PRI reclaimed the presidency in December 2012, the revolution of the political landscape in Mexico had completely eliminated any chance at a return to the old system. In the first few years of Peña Nieto's presidency, this trend towards militarization and fragmentation has continued. It would appear that the political glossing-over of the ongoing violence and corruption is symptomatic of a larger problem—the changing nature of the Mexican cartel model. The proliferation of competing drug trafficking organizations marks a new era of militarization and further break down of government control. The impact of Calderón's war and the shifting conduct of drug trafficking organizations have resulted in further decentralization continuing into the Peña Nieto administration while the splintering of previously stable organizations has resulted in an accrual of competing groups. While hegemons remain among the groups—most prominently the Sinaloa and Zeta organizations—the transformation from an old model to a new model era is evident. In assessing the distinct differences in the structural and operational variables which have characterized Mexican state and

Table 1: *Old Model vs. New Model Comparison*[19]

Operational and Structural Variables	Old Model (Pre-2000)	New model (2000-Present)
National Profit-taking from Drug Trafficking	Top-down informal system of pay-offs and kick-backs backed by PRI autocratic rule.	Democratization and multi-party system ends top-down state relationship with drug trafficking organizations.
Power Relationship between Mexican Government and Cartels	Powers of coercion held by the state. Drug trafficking organizations controlled. State functionalities maintained.	Loss of powers of coercion. Zones of impunity in regions controlled by drug trafficking organizations. Sovereignty threatened as cartels encroach on state functionalities.
Level of Cohesion between Federal, State, and Municipal Government Agencies	High level of cohesion due to homogeneity of political system.	Low level of cohesion due to multi-party rivalries and discord between agencies.
State Infiltration and Corruption	Top-down system of corruption led by PRI elite.	Corruption at lower tiers. Targeting of state and municipal forces.
Cartel Militarization	Low level of cartel militarization throughout. First sign of paramilitary escalation in 1997 with formation of Los Zetas by Gulf Cartel.	High level of cartel militarization and widespread use of paramilitary tactics. Increase in defectors from military and police forces.
State Militarization	Limited to no state militarization.	State militarization increased drastically under Calderón.
Illicit Economy	Drugs as primary source of income for drug trafficking organizations.	Drugs still a major source of income for cartels. Extensive diversification and expansion of illicit economic practices.
Number of Drug Trafficking Organizations	Relatively low number of powerful drug trafficking organizations.	Fragmentation and proliferation of numerous organizations.

criminal organizations before and after democratization, the contrast between the two models becomes clear. These stark differences between the old and new model variables are illustrated in Table 1:

As indicated in the table, during the previous century a level of cooperation between criminal organizations and the state had been maintained under the PRI. Through national profit-taking, the illicit economy was contained. Homogeneity allowed the state to enforce policies and coordinate action effectively throughout federal, state, and municipal agencies. With coercive power in the hands of the state, the economic value of drug trafficking was held in check and drugs were kept largely exterior to domestic markets. In this sense, criminal elements were subordinate to the state. Though violence existed, it was historically tolerated to the extent that it remained confined and out of the headlines. The stability brought about by state-backing in this arrangement was largely responsible for a low level of militarization despite high levels of corruption.

At the turn of the last century, the Mexican state lost this foothold. The change in political leadership and end to the PRI regime eliminated any prospect for further national profit-taking. With the advent of rapid democratization, stemming from the new multi-party system, an entirely new model was spawned. The loss of the security provided by the PRI regime resulted in a loss of stability for criminal organizations and militarization was consequently increased. Following the onset of multi-party politics, intrastate rivalries and bureaucratic destabilization crippled the state's ability to contain the violence and, ultimately, the reach of the illicit economy. As a result of this political shift, the expansion of criminal economic enterprises has given rise to violent acts perpetuated against Mexican citizenry and questions of sovereignty in cartel-occupied territories.

END NOTES

[1] Shannon K. O'Neil, "The Real War in Mexico," *Foreign Affairs Journal*, July/August 2009, p. 65.

[2] Ibid.

[3] Stephen D. Morris, *Political Corruption in Mexico*, 2009, p. 74.

[4] John Bailey, *The Politics of Crime in Mexico*, 2014, p. 146.

[5] "Mexico: Fox's Uphill Battle to Win the Drug War," *STRATFOR Global Intelligence Center*, June 29, 2005.

[6] John Bailey, *The Politics of Crime in Mexico*, 2014, p. 145.

[7] For more on the kingpin strategy, see the official U.S. Drug Enforcement Administration "History in Depth 1990-1994" at http://www.dea.gov/about/history/1990-1994.pdf

[8] Richard Fausset, "Peña Nieto team decries past drug cartel strategy — and keeps it," *Los Angeles Times*, December 21, 2012.

[9] Molly Malloy, "The Mexican Undead: Toward a New History of the 'Drug War' Killing Fields," *Small Wars Journal*, August 21, 2013. These numbers are viewed as more accurate than the statistics released by the Mexican government in recent years which have been widely criticized as being construed to politically favor the current administration. For more on the inaccuracy of official government statistics, see "Más sobre los datos de Gobernación," *Animal Politico*, April 23, 2013. An English translation can be viewed at: http://www.insightcrime.org/news-analysis/mexico-violent-crime-numbers-add-up

[10] Ibid.

[11] Patrick Corcoran, "Mexico Security Under Enrique Peña Nieto, 1 Year Review," *InSight Organized Crime in the Americas*, December 1, 2013.

[12] Sandra Dibble, "New gendarmerie in Baja California," *U-T San Diego*, September 5, 2014.

[13] "Reforms and democracy, but no rule of law," *The Economist*, November 15, 2014.

[14] Ibid.

[15] Nick Miroff, "Mass kidnapping of students in Iguala, Mexico, brings outrage and protests," *The Washington Post*, October 11, 2014.

[16] June S. Beittel, "Mexico's Drug Trafficking Organizations: Source and Scope of the Violence," Congressional Research Service, April 15, 2013, p. 9.

[17] Ibid, p. 10.

[18] Patrick Corcoran, "Mexico Has 80 Drug Cartels: Attorney General," *InSight Organized Crime in the Americas,* December 20, 2012.

[19] Author's elaboration.

REFERENCES CITED

Bailey, John. *The Politics of Crime in Mexico*. Lynne Rienner Publishers, Inc., 2014.

Beittel, June S. "Mexico's Drug Trafficking Organizations: Source and Scope of the Violence," prepared for the Congressional Research Service, April 15, 2013.

Corcoran, Patrick. "Mexico Has 80 Drug Cartels: Attorney General," *InSight Organized Crime in the Americas,* December 20, 2012.

Corcoran, Patrick. "Mexico Security Under Enrique Peña Nieto, 1 Year Review," *InSight Organized Crime in the Americas*, December 1, 2013.

Dibble, Sandra. "New gendarmerie in Baja California," *U-T San Diego*, September 5, 2014.

Fausset, Richard. "Peña Nieto team decries past drug cartel strategy — and keeps it," *Los Angeles Times*, December 21, 2012.

Malloy, Molly. "The Mexican Undead: Toward a New History of the 'Drug War' Killing Fields," *Small Wars Journal*, August 21, 2013.

Miroff, Nick. "Mass kidnapping of students in Iguala, Mexico, brings outrage and protests," *The Washington Post*, October 11, 2014.

"Mexico: Fox's Uphill Battle to Win the Drug War," *STRATFOR*,
June 29, 2005.

Morris, Stephen D. *Political Corruption in Mexico*. Boulder: Lynne Rienner Publishers, Inc., 2009.

O'Neil, Shannon K. "The Real War in Mexico," *Foreign Affairs Journal*, July/August 2009.

"Reforms and democracy, but no rule of law," *The Economist*, November 15, 2014.

U.S. Drug Enforcement Administration. "History in Depth 1990-1994."

"A Princely Expenditure of Time": The Riverside Polo Club as Conspicuous Leisure

Nicole De Silva[1,2], Catherine Gudis[1]

[1]Department of History
[2]School of Business Administration

ABSTRACT

This historical research paper examines the complex social and financial roles that local citrus growers played in the 1891 establishment of the Riverside Polo Club, an elite sporting community. At the same time, it suggests that the polo club was used to cultivate an ideal image of genteel agrarian society. To construct this argument, I draw upon a variety of primary and secondary sources, including contemporary newspapers, photographs, and artifacts; I use a visual culture approach by casting these objects as props in a larger cultural production. In addition, I examine Veblen's notion of "conspicuous leisure," explore the social nature of Riverside agribusiness culture, reveal fabricated ties between beauty and capital, and suggest complex spatial relationships between Riverside's citrus-growing valley and its downtown business district. I suggest that early Riverside fostered implicit socio-economic distinctions, which were sharpened and revealed in part by polo's material and visual cultures. To personalize this larger phenomenon, I follow and discuss the sport career of Robert Lee Bettner, the man widely regarded as the "father of Polo in Southern California." This analysis was inspired by my time spent organizing and cataloging an extensive collection of Robert Bettner's personal polo trophies, many of which can be seen on display on the upstairs landing of the Riverside Heritage House Museum. The museum, former home of Robert's mother, Mrs. Catherine Bettner, still stands at 8193 Magnolia Avenue, Riverside, California, 92504. .

Keywords: polo, conspicuous leisure, material culture, Riverside/ local history, citrus industry, physical culture, history of sport

AUTHOR

Nicole De Silva

Department of History
School of Business Administration

Nicole is a fourth year student who will graduate this spring with a B.A. in History and a B.S. in Business Administration. She currently acts as the co-Editor-in-Chief of *Audeamus* UC-Wide Journal and sits on the Honors Leadership Council. Additionally, she works as a docent for the Riverside Heritage House, where she has cultivated a love of 19th century material culture and local history. She thanks Dr. Catherine Gudis, Lynn Voorhies (Curator of Historic Structures) and Kevin Hallaran (Museum Archivist) for their expertise and mentorship.

FACULTY MENTOR

Catherine Gudis

Department of History

Catherine Gudis is Associate Professor of History and Director of Public History. She is the author of *Buyways: Billboards, Automobiles, and the American Landscape* and editor of *Cultures of Commerce: Representations of Business in America* as well as museum books on visual culture. Her interests in public history led her to found an arts and urbanism collective focused on the Los Angeles River, and to curate exhibitions and preservation projects with the Cities of Los Angeles and Riverside, Huntington Library, and UCR/California Museum of Photography, among others.

"It was pristine land then. Crystal clear air, thousands of acres of lush, rolling country with big, blue mountains on the horizon… It was a time before automobiles, and horses were a big part of life. We rode every day…. What a princely expenditure of time!" [1]

– ERIC PEDLEY, FORMER RIVERSIDE POLO PLAYER, 1977

INTRODUCTION

Founded by citrus grower Robert Bettner in 1891, the Riverside Polo Club became a site for developing manners, creating class connections, conspicuously exhibiting a wealth of free time, and associating with a state-wide leisure class. The club's material culture and architecture catalyzed the construction of an idealized agrarian aristocracy. Playing grounds, silver trophies, and newspaper photographs each present ways in which cultural notions of community and class were physically displayed and actually experienced. The club functioned as one element of the town's patrician image, fabricated to protect both social and economic interests. In this paper, I argue that polo became a means of sharpening the distinction of the local elite while attracting outside investment in the Riverside citrus industry.

METHODS

This paper uses a visual and material culture approach to examine the ways in which the Riverside Polo Club shaped and reflected dominant socio-economic ideals in Riverside at the turn of the century. According to Ardis Cameron, visual culture is composed of not only "practices of representation" such as "photography, self-fashioning, spectacle, and display," but also, "the kinds of relationships and imaginary topographies such practices composed." [2] The materials of sporting life—costumes, trophies, clubhouses, and playing fields—are cast as props in the Polo club's story. They act as markers of individual and collective identity and pride; indeed, they serve as reminders of both exclusion and cohesion amongst economic communities.

CONCEPTUAL FRAMEWORK

The eruption of polo in Riverside was hardly a historical accident: it was a response to current nationalist sentiment, the physical culture movement, and local aesthetic and economic attitudes. These concepts were deeply interrelated. Key to the physical culture movement was

Figure 1 (A526-611): The Riverside Polo Club Wins Its First Major Victory with players J.H. Woods, R.L. Bettner, C.E. Maud, and G.L. Warring, 1895.

the notion that action had the ability to shape personal character. If, according to nationalism, America's boundaries should contain a distinctly American character, then sport was perceived as a means of stabilizing and carving out its particulars. [3] In order to craft a distinct local or national identity, the task was to "find the games that had formed the so-called Anglo-Saxon" personality. [4] Though Polo was too expensive to become a mainstream marker of American identity, this decidedly Anglo-Saxon game was deemed an ideal way to construct a well-mannered American leisure class. [5] Physical culture became a means of building character on a local scale as well. Riverside's citrus elite became attracted to such markers of status for both social and pragmatic reasons: these excursions not only provided a space for institutionalizing family and personal values, but also for demonstrating an ability to manage capital.

In *Theory of the Leisure Class*, Thorstein Veblen notes that elite sport is attractive not only because it fulfills the strenuous life prescribed by the physical culture movement, but also because it allows for the construction and stratification of society. It "affords scope for emulation." [6] Making sport into a piece of personal identity seemed to be something that only the leisure class found time to do:

others could only enjoy sport as an "occasional diversion." Veblen terms such overt and "wasteful" displays of wealth "conspicuous leisure"—perhaps an ideal means of describing the Polo Club's function in Riverside.[7]

FINDINGS

The Riverside Polo Club grew out of a longstanding interest in horsemanship held by local agribusiness men. The town's athletic prowess was well-regarded throughout California: in 1915, the L.A. Examiner called the Riverside game "a horse race, a cavalry charge, a football game, and a war dance—all in one."[8] However, the journalist neglects to mention the holistic athletic culture that enveloped sporting communities.[9] New social worlds of sport—filled with teas, balls, and community events—offered unique roles to citrus growers as well as downtown dwellers, to players as well as spectators. In the history of the Riverside Polo Club, each of these groups carved out a unique space that seemed to readjust yet reaffirm social roles.

Business relationships and social connections often functioned as one in the same. Citrus was necessarily a social industry: in the *Citrograph*, a 1915 outgrowth the *Riverside Daily Press*, G. Harold Powell reveals that success in the Riverside citrus industry required "good fruit" with "good keeping quality."[10] This means that it needed to be efficiently prepared for sale at the right moment. Fruit growers in an area formed cooperatives to standardize grades, to gather information about market demand (such that they did not flood the market at the wrong moment), and to keep costs down by eliminating middlemen that might otherwise do these regulatory jobs.[11] As a result, social relationships and local information sharing defined the health of the industry. It is not surprising that the citrus growers throughout Southern California built relationships with their socio-economic peers outside of the groves.[12] Citrus cultivation required international networking as well: canals funded by British financier William Crewdson and organized by Canadian Matthew Gage provided water, the lifeblood of the groves.

Citrus formed an integral link between the economic and social life of early 20th century Riversiders. The cast of characters that made up the core of the early polo club—G.L. Warring, Robert Bettner, C.E. Maud, W.E. Pedley,

and the first formal President of the club, canal-builder Matthew Gage—each played major roles in Riverside's citrus industry.[13] Because polo required wide-open spaces and well-manicured fields, it mirrored Riverside's agricultural success.

Polo also presented an opportunity to both internally and externally market Riverside as a refined cultural center. After its first major statewide victory in 1895, the Riverside Polo Club moved to gain statewide recognition: in 1896, the team won its second Burlingame victory. According to the press, local spectatorship and pride grew ever stronger: on Washington's Birthday in 1898, "some lively racing" on the polo grounds drew "a good attendance."[14] A trophy still stands in the Riverside Heritage House Museum bearing witness to the victory of club president Robert Bettner's Lady Betty, who was generally regarded by the *Riverside Independent Enterprise* staff as "the best pony that has ever raced in Southern California.[15] The club's achievements were not limited to local grounds: in 1897, the team won the California State Championship. Riverside's athletic and cultural prowess was gaining renown.[16]

Lady Betty was not Robert's only exceptional polo mount. Two years later, in 1900, Bettner and his team would make the trip to Del Monte near San Francisco, CA to "capture the Del Monte cup" for Riverside's Polo Club. On August 22, the *Riverside Daily Press* reprinted a laudatory passage from the San Francisco Call. According to San Francisco news reporters, the triumphant success of Robert Bettner, "probably the most expert of all gentlemen riders," made the event particularly exciting for spectators. His suspenseful victory on M.E. Flower's "sweet morsel of pony flesh", Viola, was met by a "burst of applause from coaches and the grandstand."[17] An ornately carved silver trophy, inscribed with the words "From M.E. Flowers to R.L. Bettner in Commemoration of Viola at Del Monte, August 1900," remains a testimony to the good sportsmanship and collective pride of the team.[18] After winning 1/3 of the victories at the event, the Polo Team began to make a make a name for Riverside in the California press.

The year 1900 marked a major triumph for the Riverside Polo Club: the team was able to move to a far more

spacious field in Frank Miller's Chemawa Park along Magnolia Avenue. The team stayed in this space for over 20 years; it was considered to be the best field that the club had access to. It is likely that the relationship between Mission Inn-owner Frank Miller and the Polo Club was a mutually beneficial one. As one of Riverside's foremost entrepreneurs, Frank Miller likely imagined that the popular club would boost local interest in the facilities that were being constructed on his Magnolia holdings.[19] Further, given the game's traditional ties to the Old World aristocracy, Miller likely felt that directing more public attention to the team could help to embellish Riverside's image as a profitable agricultural center.

Club architecture and field landscapes, such as Chemawa Park, functioned as key elements in the development of the polo club. Of course, the game requires a wide-open space for practicing and playing. The spatial layouts and designs of the Polo Club lands and fields reveal certain beliefs of the men who designed and funded them.[20] Citrus planter J.H. Reed extolled this "great industry" of orchard growth as something that was not only economically productive, but also a "pleasing, and beautiful" centerpiece for the Riverside social community.[21]

J.H. Reed suggests that the condition of working with (or owning) beautiful fruit orchards simply "affect one's" tastes. Reed tells readers of *The Citrograph* that "the matter of everyday association with objects connected with our occupations that are pleasing and beautiful has more to do with our everyday enjoyment than most of us stop to realize."[22] For Reed, an association with the great outdoors heightened and civilized the citrus grower's sense of aesthetics. Archie Shamel, pictured with Bettner in the figure at right, believes that "cultivated taste" was "inherent in the culture of the orange." Growers combined civilized "outdoor living" with an "appreciation for natural beauty."[23]

Robert Bettner and his team may not have been consciously aware of their contribution to the aesthetic mythos of Riverside; it is likely that the men played the sport out of personal enjoyment. Yet, as J.H. Reed suggests, their perception may have been shaped by the beauty of their natural environment. Very likely, Robert Bettner was interested in playing polo as an athletic contest; indeed, his personal history reveals an avid interest in sportsmanship that predates the establishment of an elite sporting or leisure culture. However, it is likely that reporters, photojournalists, and entrepreneurs such as Frank Miller each appropriated polo as a symbol of the local "romance of the orange." For example, Miller placed the club in Chemawa Park at the end of his streetcar line. In this way, the field functioned as an excellent punctuation

Figure 2: (A400-27) The back of this photograph is marked by Robert's daughter: "Archie Shamel, Famed Palmologist at Citrus Experiment Station. (left); Robert Bettner, Polo Player and Real Estate (right)."

of his narrative journey of Riverside; it epitomized the "romance of the orange" and the region's rarified social culture. It represented a symbolic connection between the urban and the rural.[24]

Figure 3: The Gymkhana Games gave women, such as Robert's daughter Dorothy (second left) a chance to play on the field (albeit in a clearly marked and separated role). Photo entitled "Ladies who threaded needles for Poloists in the Thread-Needle Contest" from the July 1910 San Francisco Call.

The polo club celebrated a golden era from the year 1900 to 1917. According to an interview with Robert Bettner conducted by the L.A. Examiner in 1917, spectators had grown to crowds of thousands after the move to Chemawa Park. Bettner worked tirelessly to "popularize polo" by "giving the people what they promised them"—a riveting athletic and capital display. Other athletic contests also took place for public amusement.[25] For example, "gymkhana games," which are defined as "an outdoor gathering for

purposes of recreation… in which horses of any sort take part" became a popular attraction at Chemawa Park.[26] The polo club began these events around 1894—over twenty years before they appeared on a professional or statewide scale. One particularly popular Riverside invention was the "Cigar and Umbrella Race," as played on New Year's Day of 1906:[27]

> "The conditions are that each contestant must light a cigar, open an umbrella, mount his pony, and ride a hundred yards to a stake. He must then turn this stake and ride back. At the finish his cigar must be lit and umbrella intact."[28]

The 1906 games were part of a longer tradition. Each January 1, Chemawa was the site of a New Year's Tournament and race program. In 1908, "the popularity of Polo and Gymkhana sports in Riverside was thoroughly attested by the large crowd" which gathered to view what the Press considered to be very "snappy playing." As usual, writers report that "Bettner was the shining star of the period." He took home a two-handled silver-plated trophy commemorating his team's performance at the event.[29] Chemawa Park also included a collection of other amusements, including a pavilion to be used as "a charming retreat for picnics, dancing parties, and summer evening concerts."[30]

Figure 4 (A400-86): The grandstand at Chemawa Park, which, according to The Riverside Enterprise, had a space for spectators (or, "enthusiastic admirers of the sport") in automobiles.

The Sherman Institute for Native American students was directly adjacent to Chemawa Park. It is possible that Miller designed his street car line in a way that would allow him to capitalize on California's romanticized Spanish Colonial heritage. The polo grounds, the Sherman institute, and the Mission Inn may all be seen as part of Miller's entertainment program that celebrated a mythologized Californian past of genteel agrarian patriarchs, amiable Spanish missionaries, and affable relationships with Native Americans.[31] Often, the Institute Band would play between polo games as part of the spectacle.[32] Given its juxtaposition with the Sherman school, the polo grounds became a site of casting not only racial difference but also colonial inculcation: the student band became a symbol of assimilation at work.

DISCUSSION

The Chemawa Park facilities were able to reveal certain class distinctions that may have otherwise remained invisible. Most class stratifications were communicated quite bluntly: During the 1908 New Year's Tournament, the press made certain to note that "the grandstand and bleachers were packed with Riverside's best people"—likely, local businessmen and prominent growers. However, not only the wealthy turned out to see fellow Riversiders play—"nearly as many more [average citizens] stood on the ground space." Local sporting interactions reveal that there were subtle distinctions within those divisions.[33]

In 1966, Riverside historian Wilkie B. Leake proposed an often-overlooked socio-economic tension between the "town" and "valley" people. He suggests that, while the businessmen, bankers, estate agents, and other white-collar workers and managers in the town center had an interest in the agricultural success of Riverside, the citrus growing class disassociated itself with what it regarded as an inferior pecuniary group. Riverside was steeped in Jeffersonian ideals of "producerism," which celebrated the ability of growers to turn untapped resources into capital. Writing in the 1915 *Citrograph*, citrus researcher Archie Shamel lauds the growers' remarkable industriousness, saying that:

> "Someone has said that man is a public benefactor who causes two blades of grass to grow where but one grew before. What, then, can be said of the pioneers of the navel orange industry who cause grass and fruits and flowers to grow where NONE grew before?"[34]

By casting themselves as public benefactors and creators of both public wealth and beauty, the Riverside "valley people" constructed a social order in which they rested firmly at the top.

The town/valley distinction is often typical of capitalist societies. In the language of Thorstein Veblen, the valley people were an industrial class: their groves created new capital. The town people, however, practiced exploit—the process of turning that base capital into useable goods, information, or some other valuable product. Certainly, given the thousands of acres of citrus that specked the Inland Empire's landscape, the valley residents owned a great deal more productive resources than their downtown counterparts. As Veblen writes, "those who have to do immediately with ownership on a large scale are the most reputable of economic employments proper."[35] The town people, having "those employments that are immediately subservient to ownership and financiering—such as banking and law," rank a close second, followed by mercantile pursuits.[36] Polo, as a form of conspicuous leisure, made these inner-class stratifications clear: regardless of income, businessmen in the town center could never find the time or space to become full, playing members of the Polo Club.

Members of the valley group imagined themselves as cultural and even biological heirs to the legacy of landed, British aristocracy. In his poem, "Song of the Red and Black," Riverside player R.M. Schwartz adopts the democratic ideal of "fighting together like brother and brother" yet marks a very aristocratic kind of brotherly companionship: "with hearts aflame to win the game," he invokes "breeding blue" as a key element in the "raid for the enemy's goal."[37]

Ironically, it became impossible for Riverside to sustain its own system of distinction: though the game began as an amateur sport, it became increasingly professionalized by the end of the 1910s. Though a reasonable polo mount cost only $25 in the 1890s, a truly competitive pony could fetch up to $2,500 by 1915.[38] As a relatively small agricultural town, Riverside growers found themselves unable or unwilling to continue investing in their equestrian hobbies. Further, many of Riverside's star players were drafted into the First World War. From 1917-1919, Miller converted the Chemawa Park field into a Junior High School. Popular

interest in the sport's former pageantry waned as America's Gilded Age faded in the midst of wartime realities.

Riverside's elite sporting community was only one element of local culture. Yet, as a representative slice of a whole, it has the potential to reveal complicated tensions, alliances, and economic interests that might otherwise remain invisible. Polo facilitated ties between business alliances and social relationships. Using architectural and spatial markers of status, players constructed a citified country that revealed Riverside as worthy of investment and full of socio-economic potential. The sport field became a stage upon which Riverside's citrus growers could construct an image that would attract necessary outside investment. Without imported water, capital, and labor, Riverside could not have developed the "rolling country with big, blue mountains on the horizon" that the players so fondly recall.[39] Polo began as a leisure activity that drew from the physical culture movement; yet, it quickly took on a mythology of its own. It became an emblem of Riverside's leisure class and socio economic institutions.

WORKS CITED

Borish, Linda, & Phillips, Murray G. "Sport History as Modes of Expression: Material Culture and Cultural Spaces in Sport and History," *Rethinking History*, Vol. 16 (4), December 2012, pg. 465-477.

Cameron, Ardis. *Looking for America: The Visual Production of Nation and People*. Malden, MA: Blackwell Publishing, 2005.

Mrozek, Donald J. *Sport and American Mentality*, Knoxville, TN: University of Tennessee Press, 1983.

Ruddock. Margret. "Living Legend in Belvedere: Interview with Eric Pedley," *The Official Publication of the U.S. Polo Association*. Vol. 3 (3), 1977.

Mayo, Richard. *The American Country Club: Its Origins and Its Development,* Rutger's University Press: New Brunswick, 1998.

Patterson, Thomas. *A Colony for California: Riverside's First Hundred Years,* Riverside, CA: The Museum Press of the Riverside Museum Associates, 1996.

Veblen, Thorsten. *Theory of the Leisure Class*, New York, NY: The Modern Library, 1934

Newspaper Publications:

Riverside *Citrograph*, May 20, 1915

Riverside Daily Press, August 22, 1900,
December 26, 1903

Riverside Independent Enterprise, December 30, 1903,
January 2, 1908, February 9, 1915

Riverside Press and Horticulturalist, April 15, 1902

San Francisco Call, July 1910

Unpublished Dissertations:

Hartig, Anthea Marie. *Citrus Growers and the Construction
of the Southern California Landscape,* 1880-1940. PhD
Thesis, University of California, Riverside, 2001.

Gonzales, Nathan Daniel. *Visit Yesterday Today*. PhD Thesis,
University of California, Riverside, 2006

Leake, Wilkie B. A *Short History of the Riverside Polo Club*.
BA Honors Thesis, University of California Riverside, 1966

Artifacts:

Riverside Metropolitan Museum Archives, Bettner Family
Collection

Documents: Annual General *Meeting of the Riverside
Polo Club* held at Mr. Hotson's House, Indiana Avenue,
Meeting Minutes of the Riverside Polo Club, Handwritten
Manuscript, 1895.

Polo Trophies: A526-463, A426-466, A526-472, A526-474,
A526-477

Photographs: A400-27, A400-86, A849-127

Footnotes:

[1] Margaret Ruddock. Interview with Eric Pedley from *The Official Publication of the U.S. Polo Association*, "Living Legend in Belvedere," Vol. 3 Issue 3. (1977)

[2] Ardis Cameron. *Looking for America: The Visual Production of Nation and People*. (Malden, Blackwell Publishing 2005), pg. 11

[3] Donald J. Mrozek. *Sport and American Mentality*, (Knoxville, TN: University of Tennessee Press ,1983): pg 165

[4] Mrozek, *Sport in American Mentality*, pg. 166

[5] Handbook of the National Polo Association (1919), p. 115. Retrieved from the Riverside Metropolitan Museum Archives

[6] Thorsten Veblen, *Theory of the Leisure Class*, (New York, The Modern Library, 1934): p. 258.

[7] Velben, pg. 92. Conspicuous leisure is "honorable... because it shows exception from ignoble labor."

[8] L.A. Examiner, n.d., Clipping retrieved from the Riverside Metropolitan Museum Archives.

[9] "Bettner Won at Del Monte," *Riverside Daily Press*, (Riverside, CA: August 22, 1900), pg. 3. Reprinted from *San Francisco Chronicle, August 19, 1900.*

[10] G. Harold Powell, "The California Fruit Grower's Exchange," Citrograph, pg. 12

[11] Ibid, pg. 13

[12] Reed J.H., "The Riverside Horticultural Club," *Citrograph*, Vol LI, No 120 (20 May 1915): 6.

[13] Patterson, *Colony for California*, pg 222

[14] Text from "Some Lively Racing," *Riverside Independent Enterprise* (Riverside, CA: 23 February 1898): p. 3

[15] Riverside Metropolitan Museum Archives, Heritage House, Bettner Family Collection, Item A526-477.

[16] Leake, Wilkie B. "A Short History of the Riverside Polo Club," (BA Thesis, UCR, 1966) p. 14

[17] "Bettner Won at Del Monte: Captured the Del Monte Cup," *Riverside Daily Press*, (Riverside, CA: August 22, 1900), p. 3.

[18] Riverside Museum Archives, Heritage House, Bettner Family Collection, Item A526-466

[19] Leake, Wilkie. "A Short History of the Riverside Polo Club," (BA Thesis, UCR, 1966), p. 12

[20] Cited in Linda Boorish and Murray G. Phillips, "Material Culture of Sport," *Rethinking History* Vol 16, No. 4, December 2012, 465-477.

[21] J. H. Reed, "Influence of Citrus on Community Beautification," *Citrograph*, (Riverside, CA: May 20, 1915): pg. 8

[22] J. H. Reed, "Influence of Citrus on Community Beautification," *Citrograph*, (Riverside, CA: May 20, 1915): pg. 8

[23] Shamel, "Esthetic Side," No. 1 (January 1928). Cited by Hartig, *Citrus Growers*, 359.

[24] Nathan Daniel Gonzales, *Visit Yesterday Today*, (PhD Thesis, UCR, 2006) pg. 82

[25] "To Popularize Polo," *Riverside Enterprise*, (Riverside, CA: February 9, 1915). Pg. 2

[26] Arthur Inkersley, "First Genuine Gymkhana in California Held at Coronado," *San Francisco Call*, Vol 108 (47), 1910, pg 16

[27] Riverside Museum Archives, Heritage House, Bettner Family Collection, Item A526-474

Nicole De Silva

Footnotes (cont.):

28 "Polo Club Plays Another Gymkhana," *Riverside Independent Enterprise*, (Riverside, CA: December 30, 1903), p. 5

29 Riverside Museum Archives, Heritage House, Bettner Family Collection, Item number A526-472

30 "Improving the Park," *Press and Horticulturalist*, (Riverside, CA: April 15, 1902). Pg. 8

31 Gonzales, V*isit Yesterday Today*, (PhD Thesis, University of California, Riverside, 2006): pg 83

32 "To Popularize Polo," *Riverside Enterprise*, (Riverside, CA: February 9, 1915). Pg. 2

33 "New Year's Tournament at Chemawa Largely Attended," *Riverside Enterprise*, (Riverside: CA, January 2, 1908).

34 Archie D. Shamel, "The Washington Navel Orange," *Citrograph* (Riverside, CA: May 28, 1915), p. 4.

35 Veblen, *Theory of the Leisure Class*, pg. 231

36 *Ibid*, pg. 231

37 R.M. Swartz, "Song of the Red and Black," *Riverside Enterprise* (Riverside, CA, February 9, 1915): 2

38 Wilkie B. Leake, Short History of the Riverside Polo Club, (BA Thesis, UCR), pg 21.

39 Margaret Ruddock. Interview with Eric Pedley from *The Official Publication of the U.S. Polo Association*, "Living Legend in Belvedere," Vol. 3 Issue 3. (1977)

"All people think us mad": Expression, Protest, and Healing in the Poetry of *The Hydra* at Craiglockhart War Hospital

Deanne Elliot[1,2], Jonathan Eacott[2]

[1]*Department of Political Science*
[2]*Department of History*

ABSTRACT

Poetry became a popular avenue of expression for soldiers during the First World War as a way to comprehend traumas experienced at the front. In particular, injuries such as shell shock affected soldiers not only physically but emotionally and psychologically, and poetry became a way of reordering those mentally trying experiences, and therefore part of the healing process. Craiglockhart, a hospital located near Edinburgh and dedicated specifically to treating officers with shell shock, printed *The Hydra* from 1917 to 1918, a journal with contributed works from the patients including poetry, editorials, stories, and concert reviews. This research examines the major thematic categories of the poetry printed in the seventeen issues of *The Hydra*. The officers' poetry in the journal reflects their feelings toward the war, their recovery, other soldiers, and the feelings of otherness caused by their injury and their subsequent positioning in a psychiatric hospital. The hospital was distanced from both the war front and the home, but officers were, at the same time, building new relationships with fellow patients suffering similarly. Special attention is paid to the esteemed war-poets Wilfred Owen, who edited *The Hydra* for a time and contributed numerous works, and Siegfried Sassoon, whose relationship with Owen initiated at Craiglockhart greatly contributed to Owen's growth as a poet.

Keywords: First World War; Wilfred Owen; Siegfried Sassoon; poetry; Craiglockhart; shell shock; The Hydra

AUTHOR

Deanne Elliot

Department of Political Science
Department of History

Deanne Elliot is a fourth year student majoring in Political Science and History. Deanne's research with Dr. Eacott was a chance to explore a unique part of World War I literary history. Besides completing her Honors Capstone Project on World's Fairs, Deanne is honored to be in Phi Beta Kappa and a Chancellor's Leadership Fellow. She will continue her education at Pepperdine School of Law. The author thanks Dr. Eacott for his support, as well as her family and friends for their love.

FACULTY MENTOR

Jonathan Eacott

Department of History

Jonathan Eacott is an Assistant Professor of History. He has received several research awards for his work on the British and their empire from the eighteenth century to the present. He is the author of Selling Empire: India in the Making of Britain and America, 1600-1830, which uncovers the vital importance of India in the economic, political, and cultural development of the British empire in the Atlantic Ocean and, later, the early American Republic.

Deanne Elliot

The First World War is widely known for inspiring artistic expression as a way to combat and respond to the faceless nature of modern warfare, and poetry was one of the major areas in which such expression occurred. More than just artistic expression, however, for educated "officer-poets," poetry was a way to heal from psychologically traumatic incidents like shell shock, an early diagnosis of what is now known as post-traumatic stress disorder, which resulted in symptoms ranging from troubled sleep to "linguistic ruptures."[1] Shell shock was an all-purpose term for a complex problem that affected 28,533 soldiers between 1914 and the end of 1917, the War Office conservatively estimated.[2] Focusing on the use of poetry at the Craiglockhart War Hospital near Edinburgh is aided by the availability of *The Hydra*, the hospital's patient-run journal, which printed contributions from such esteemed war poets as Wilfred Owen and Siegfried Sassoon, and was edited for a time by Owen.[3] The poetry of *The Hydra* is useful as a peek inside the minds of Craiglockhart patients as poetry was an important part of Dr. Brock's "ergo-therapy," which, Meredith Martin argues, required the officer to reconnect to the social world that they mentally deserted in their traumatic experiences.[4] Dr. Brock, who assigned the editorship to Owen as part of his convalescence, encouraged poetic work as an "empowering method of controlling time" for the officers to begin remaking those connections.[5]

Examined thematically, the poems in *The Hydra* are a looking-glass into the officers' attempts to articulate their traumatic experiences as part of the healing process but also express their skepticism in the efficacy of such practices. The letters of Wilfred Owen contribute to the broader context of the officers' poems that reflect unique understandings of the war and their place in it. Owen's stay at Craiglockhart, Daniel Hipp explains, was transformative for his poetic life because of his relationship with Sassoon and because of the works he undertook as part of the healing process, which meant "forging a public voice [to speak] for those whom war has rendered incapable of speaking for themselves."[6] The poetry in *The Hydra* contributes to our understanding of the officers' experiences, and suggests that poetic expression and healing was not limited to such talents as Sassoon and Owen. The poems range from melancholy and dark to humorous and light-hearted, reflecting different aspects of the Craiglockhart officers' wartime and hospital experiences, and their distance from both home and the front. They are therefore worthwhile

to analyze with the understanding that being in a hospital is essentially a liminal experience, particularly one designated for shell-shock patients. The poetry printed in *The Hydra* illustrates various ways officers at Craiglockhart internalized and then expressed their thoughts and experiences as shellshock patients within the hospital, illustrating the haunting effects of the modern, technological warfare that became so emblematic of the First World War.

One major theme in *The Hydra's* poetry is nature in her countless forms, negotiating a number of concerns about the war: the loss of innocence and purity that must be re-found in nature, then celebrated and returned to; and nature as metaphor for the dichotomy of evil and good, that was confused by the attrition of the war. In "A Shattered Hope" by Synjin, nature is personified as a mother who "takes back the life of a dead world," and brings a "new one…from her depth."[7] The purity of a mother-earth offers redemption for the injury inflicted on her by the war and forgiveness to those complicit in her attack by bringing forth a new world for them to inhabit. Authors deployed nature as a poetic tool to signify the lost purity that must be re-found for the proper cleansing of their tortured souls that prevented sound sleep and the return of whatever joy they knew before going to the front.

More pointedly, Siegfried Sassoon used nature as a direct counterpoint to express his belief in the war's futility – feelings that got him sent to Craiglockhart in the first place. Sassoon, a published author before his stay at Craiglockhart, was hospitalized for sending a very strong message to High Command about his disgust at the wanton destruction of the war after witnessing the Battle of the Somme in 1916.[8] Wilfred Owen was an ardent admirer of Sassoon's, and it was because of their friendship that Owen became the poet he did. Sassoon's advice to Owen was to "Sweat your guts out writing poetry!" inciting him to harness his darkest memories that enabled his development as a spokesman for other soldiers who could not speak for themselves.[9] Sassoon's cynicism about the war, and anger about its justification along moral and religious grounds, is presented in contrast with the purity of nature in "Thrushes,"

> Tossed on the glittering air, they soar and skim,
> Whose voices make the emptiness of light
> A windy palace. Quavering from the brim
> Of dawn, and bold with song at edge of night,

They clutch their leafy pinnacles and sing,
Scornful of man and from his toils aloof;
Whose heart's a haunted woodland whispering,-
Whose thoughts return on tempest-baffled wing,-
Who hears the cry of God in everything,
And storms the gate of nothingness for proof.[10]

The birds, the main actors of the piece, epitomize the beauty and freedom and purity of nature; they stare aghast and "scornful of man" and his aim in killing other men on a mass scale. The last two lines are by far the most damning, condemning the men who seek to shroud their pointless, blood-thirsty actions with religious sanctity, easily interpreted here as the same type of pointless action that characterized the struggle over miles of trench-lines on the Western front. Sassoon characterized the war as the antithesis of nature, as everything unnatural, technological, modern, and therefore not only impure, but also destructive of that innocence. His beliefs were shared by Dr. Brock who also saw "the mechanizations of modern war as inherently unnatural" and "sought to reconnect his patients to their...natural environments."[11] The pieces concerned with nature, though not always direct in contextualizing the war, have an underlying attachment to the devastating effects of the war upon the officers personally, and nature and mankind generally.

Perhaps the most haunting recurring theme is that of the soldiers' experiences, including not only actions at the front, but also the emotional and physical distance between the soldier and society, the home front and battle front. As Martin notes, Dr. Brock "forc[ed] the patients to actively and metrically order their mental chaos in new contexts of time...the five-beat line of a poem, a first-person narrative or short-story," allowing them to reconstitute their "connection with the larger community of English writing and of Britain in general."[12] Undoubtedly, poems that articulated war-time experiences printed in *The Hydra* were likely the result of Dr. Brock's therapy methods. However, despite Dr. Brock's intentions, some works, rather than reflecting a re-connection to society, instead serve to highlight the difficulties of doing so.

A good amount of the poetic work in The Hydra narrates specifically the officers' efforts to contend with the psychological trauma they suffered at the front. One

form of this was writing about the hospital routines that permeated their existence. These works in particular are intensely emotional and incredibly self-aware. One such work, a very short untitled and uncredited poem, speaks to the nightmares that tormented patients at Craiglockhart.

Turn out!
Hark to the fearsome shout.
What is it? Fire or flood?
Or awful battle rout?

Nay, gentle stranger, calm
Your dread. That great alarm
Means only that it's time to rise,
Tis Sister ---'s morning psalm.

The soldier in this brief piece wakes from battle-filled dreams to the nurse's morning prayers, leaving the battlefield in the mind for the religious routine of the hospital, yet is unable to reconcile them in his subconscious. This poem reinforces the feeling of limbo resulting from the inevitable realization upon waking from haunted dreams that they were actually in the hospital for that very reason. Sassoon labeled Craiglockhart as "full of men whose slumbers were morbid or terrifying," and Owen described the recurring dream sensation as one of "going over the top...about as exhilarating as those dreams of falling over a precipice, when you see the rocks at the bottom surging up to you."[14] The officers skillfully utilized and articulated their experiences not only to help themselves heal psychologically, but to express their pent up rage at their futility and the destructive power of the war that rooted itself deep in their subconscious.

Some of the poems articulate directly the 'otherness' caused by their stay at Craiglockhart, a facility designated for "Neurasthenic Officers."[15] While the men were encouraged to take up a variety of activities inside the hospital and in the local community, they expressed through their poetry and Owen likewise expressed in his letters how outside of society they felt, despite their best efforts to resume a normal role.[16] One poem in particular makes this sentiment abundantly clear, entitled "Stared At," and signed "An Inmate,"

I've got a blue band on my arm,
But surely that's not any harm...
No wonder that my nerves ain't right,

I'm stared at.

Craiglockhart mem'ries will be sad,
Your name will never make us glad;
The self-respect we ever had
We've lost - all people think us mad.[17]

Without a doubt, this "Inmate" directly challenges the hospital's practices which, for him, only serve to segregate rather than reintegrate him back into society. The unfortunate logic of shell shock was that it did not always manifest itself visible. Owen, for example, suffered initially from a slight stammer, but his nightmares remained long after.[18] And as a result, he noted a similar experience to the "Inmate" during his forays into the town near the hospital, writing to his mother that "I am looking so well as to cause remarks to be made as I pass the guid wives in the town."[19] Beyond the judgmental stares of others, however, Owen also recorded in his letters that he felt caged in distinct roles that alienated him from normal society, "I am a sick man in hospital, by night; a poet, for quarter of an hour after breakfast; I am whatever and whoever I see while going down to Edinburgh on the tram: greengrocer, policeman, shopping lady… all of these in half an hour..."[20] This "fragmented identity" was likely common among Brock's patients because his methods required participation in numerous activities meant to rebuild that connection to society in order to normalize their traumatic experiences.[21] Despite the friendships they developed within the hospital, illustrated especially by Sassoon and Owen, this social reconnection with the wider, non-military community was critical because shell shock, in essence, was "a flight from [the] intolerable reality" of the trenches or their memories of them.[22] But despite these many social roles, poems like the Inmate's unambiguously describe the inherent difficulty of trying to reconnect with society from the liminal space of the hospital.

Siegfried Sassoon's "Dreamers" is a potent exemplar of the longing for home that each soldier likely felt, and of which they were made more and more aware by the horrors of the trenches: "Soldiers are dreamers; when the guns begin/ They think of firelit homes, clean beds, and wives."[23] Sassoon essentializes the wants of soldiers into three basic comforts that the men at the front are denied – warmth, a place to rest, and their beloved – and from which they are distanced by the very guns that remind them of it. He compounds the trauma of this separation by following the soldiers' 'dreams' with the tragic evidence that they are, instead, "in foul dug-outs, gnawed by rats/...Dreaming of things they did with balls and bats..."[24] Not only are the trenches painted as thoroughly disgusting for the reader, but mundane things become iconic of the desire to be home. By far one of the most eloquent contributors to *The Hydra*, Sassoon's work is critical in identifying the dichotomy of home versus war front, and reinforces the in-between nature of a hospital stay that distances one emotionally and physically from both.

A uniquely poignant aspect of the poetry illustrating life in the army presented the officer's attention to the men in their unit, and their concern about perceptions of soldiers on the home front. One of these works is the accented poem "Any Private to Any Private," credited simply to S. The piece reflects the harsh reality of the men in the trenches through the conversation of two working class soldiers discussing the impact of the war on the family of a third, "We joined the gither for a bob a day;/An' noo he's deid.../I canna mak' it oot. It fair beats a',/That Wullie has tae dee for God kens what." They go on to relate the impact of Wullie's death on his wife, whose treatment by the state is deplorable in light of her husband's sacrifice for its cause. "An' Wullie's wife'll get a bob or twa,/ Aifter they interfer wi' what she's got./ They'll pester her, and crack a dagoned lot'/ An' Heaven kens, they'll lave her awfu' ticht./ 'A burden to the State.' Her Wullie's shot..."[25] While more likely than not this conversation between the speaker and Davie was fictitious or cobbled together from the officer's memory, it still illustrates a degree of attention paid by the officers to the situation of their men that suggests a sense of comradery despite the highly stratified and elitist nature of the British army and society. The overall implication is that the war, particularly a war fought in the hellish mud of the trenches, affected everyone regardless of class, and that the state dealt unfairly with those whose family members they sent to die.

Numerous poems in *The Hydra* of a humorous or satirical nature are equally direct and biting commentaries about the war, and range in variety more than any other poetic theme in the journal. The common theme of liminality is harder to find, particularly in the piece written from the perspective of a dog, but even the seemingly trivial pieces implicitly articulate the desire to return home or even go back to the front and face

the uncivilized 'Huns'. "The Dachshund's Lament," credited to C.H.M., is a similarly accented piece like "Any Private to Any Private," but rather relates the account of a dachshund, the pet of "mein mistress."[26] The note introducing the poem indicates, perhaps facetiously, that there was apparently some discussion during the period about whether the German dachshund breed was actually an English turnspit or badger-hound breed.[27] Playing with this, the dachshund claims to be English but on the side of Germany, claiming it is the fault of the "cruel English" who "make der var" upon the "cultured Huns," employing the common rhetoric of the English in referring to the Germans. The attempt at an accent implies the author sought to portray a humorous subject, but still impregnated the poem with simultaneously patriotic language that ridicules the Germans even on such a minute level as their dog breeds.

Besides accented poems, other contributors utilized humorous subjects or juxtapositions as a way to comment upon the range of reactions to the war on the home front. Wilfred Owen's "The Dead Beat," though not published in finished form in *The Hydra*, was printed in part in one of his editorials, prefaced by the snarky note that "In this excellent Concentration Camp we are fast recovering from the shock of coming to England."[28] Only one stanza of the poem is published, but even in brief, still rails against the war and the public's reactions to, and media's representations of, the war, "The exempted shriek at Charlie Chaplin's smirk./ The *Mirror* shows how Tommy smiles at work./ And if girls sigh, they sigh ethereally,/ And wish the Push would get on less funereally."[29] Though humorous, the lines cut to Owen's dismay at the perceived indifference of the nation to the death reigned on soldiers at the front. Hipp likewise notes that "the ignorance of the civilian populace... became an enemy more loathed than the Germans to many soldiers in the trenches."[30] The girls bemoan their loss, but do so "ethereally," unattached to the reality of the fighting, and "the exempted" are dealt a particularly harsh blow by Owen. As portrayals of different persons on the home front, these lines reflect the 'otherness' that stigmatized the returning soldiers, that made it difficult to return to normal, uncaring, society.

The last work included in this analysis is by far the sharpest commentary, such that it is witty only in its execution, but certainly not in subject or implication. Again, as Siegfried Sassoon was such an outspoken critic of the war, it is not surprising that the most biting works belong to him. "Base Details" continues in that tradition:

> If I were fierce, and bald, and short of breath,
> I'd live with scarlet Majors at the Base
> And speed glum heroes up the line to death.
> You'd see me with my puffy, petulant face,
> Guzzling and gulping in the best hotel,
> Reading the Roll of Honour.
>   "Poor young chap,"
> I'd say - "I used to know his father well.
> Yes, we've lost heavily in this last scrap."
> And when the war is done, and youth stone dead,
> I'd toddle safely home and die - in bed.[31]

Sassoon is quite explicit. All commanders are generalized into the character of the speaker, and are not only physically grotesque, but are also willing to sacrifice those they knew personally, not to mention the hundreds of thousands they did not. They are greedy and gluttonous, and they rush unenthusiastic but patriotic men (the actual heroes) to bloody, muddy, early graves; they are undeserving of command and deserving instead of death themselves. This is no less than a stinging indictment of every practice followed by nearly every belligerent country during the war. Sassoon rebelled against the unnatural aspects of the war in "Thrushes," and here as well he takes to task the flippant regard with which human life was expended.

Notably, Sassoon's poetry expressed more stinging, explicit anti-war views, whereas Owen, and many of the contributors to *The Hydra*, vocalized negative, but still personal or patriotic motives for fighting, despite their injuries. Owen expressed a desire to gain "some reputation of gallantry" prior to being able to "successfully and usefully declare my principles," recognizing a political need to gain credibility as a soldier before expressing his beliefs.[32] Hipp argues that Owen desired to return to the front after Craiglockhart in order to record the suffering of his comrades so he could "speak of them as well as a pleader can," directly through his poetry.[33] Even before returning to the front, however, Owen actively used memories of his time in the trenches for his poetry such that he could "almost see the dead lying about in the hollows of the downs."[34] Regardless of their position or inclination to denounce the war, in their efforts to heal, contributors to *The Hydra* wrote from the images captured in their subconscious.

The contributors to *The Hydra* told stories and verbalized sentiments about their struggles during their time in battle and at Craiglockhart. Their works negotiated life and death, home and the front, love and loss, nature and war, sometimes in harmony, sometimes in opposition. Expressing themselves through wit or grave imagery was more of a stylistic decision, and no common stylistic threads run through the works. But to almost complete exclusion, the works in *The Hydra* contain the underlying theme of isolation, within themselves, from other soldiers, from other injured, from their families, from society; they all meditate on the inherent loneliness of their position in the hospital, and their distaste or confusion about the war. Remarkably, while the officers disliked Craiglockhart, they held the friends they made there as invaluable. After returning to light duties, Owen shared with Sassoon that "[w]hat I most miss in Edinburgh (not Craiglockhart) is the conviviality of the Four Boys."[35] Craiglockhart, then, was not lonely for lack of activities or friends. Rather, a stay in the hospital was difficult because soldiers were forced to dredge up the most horrific memories in an attempt to order and normalize them, in addition to the physical and emotional residue of the trauma they had experienced and their distance from home or the front. The officers of Craiglockhart attempted to harness their ghosts and put them on paper. How they appeared varied widely, but the poetry in *The Hydra* captured the officers' feelings of liminality, dismay and disgust at the war in general, and their experiences in particular.

REFERENCES

Hipp, Daniel. "'By Degrees Regain[ing] Cool Peaceful Air in Wonder': Wilfred Owen's War Poetry as Psychological Therapy." *Journal of the Midwest Modern Language Association* 35, no. 1 (Spring, 2002), 25-49.

Hipp, Daniel. *The Poetry of Shell Shock: Wartime Trauma and Healing in Wilfred Owen, Ivor Gurney and Siegfried Sassoon* (Jefferson, North Carolina: McFarland & Co., 2005).

The Hydra: Journal of the Craiglockhart War Hospital (April 1917 – July 1918). Accessed in the First World War Poetry Digital Archive.

Martin, Meredith. "Therapeutic Measures: "The Hydra" and Wilfred Owen at Craiglockhart War Hospital." *Modernism/Modernity* 14, no. 1 (January 2007), 35-54.

Owen, Wilfred. *Wilfred Owen: Selected Letters*, edited by John Bell (Oxford: Oxford University Press, 1998).

Owen, Wilfred. *Wilfred Owen: Selected Poems and Letters*, edited by Helen Cross (Oxford: Oxford University Press, 2009).

Footnotes

1 Meredith Martin. "Therapeutic Measures: *The Hydra* and Wilfred Owen at Craiglockhart War Hospital." *Modernism/Modernity* 14, no. 1 (January 2007), 36-7.

2 Daniel Hipp. *The Poetry of Shell Shock: Wartime Trauma and Healing in Wilfred Owen, Ivor Gurney and Siegfried Sassoon* (Jefferson, North Carolina: McFarland & Co., 2005), 7.

3 Martin, "Therapeutic Measures," 44.

4 Ibid, 37; 41.

5 Ibid, 37.

6 Hipp, *Poetry of Shell Shock*, 11.

7 *Hydra*, July 7, 1917, 11.

8 Wilfred Owen, *Selected Letters*, edited by John Bell. (Oxford: Oxford University Press, 1998), 270. Hipp, *Poetry of Shell Shock*, 12-3.

9 Owen, Selected Letters, 271; Daniel Hipp, "'By Degrees Regain[ing] Cool Peaceful Air in Wonder': Wilfred Owen's War Poetry as Psychological Therapy." *Journal of the Midwest Modern Language Association* 35, no. 1 (Spring, 2002), 32.

10 *Hydra*, November, 1917, 15.

11 Martin, "Therapeutic Measures," 42.

12 Ibid, 41.

13 *Hydra*, May 26, 1917, 16.

14 Owen, *Selected Letters*, 262; 243.

15 "Wilfred Owen in Context" in *Wilfred Owen: Selected Poems and Letters*, edited by Helen Cross (Oxford: Oxford University Press, 2009), 12.

16 Owen, *Selected Letters*, 262.

17 *Hydra*, June, 1918, 12.

18 Hipp, "By Degrees," 27; 29.

19 "Wilfred Owen in Context," 12; Owen, *Selected Letters*, 260.

20 Owen, *Selected Letters*, 279; 265.

21 Hipp, "By Degrees," 31.

22 Ibid, 30.

23 *Hydra*, September 1, 1917, 10.

24 Ibid.

25 *Hydra*, November, 1917, 9.

26 *Hydra*, May 26, 1917, 10.

27 Ibid.

28 *Hydra*, September 1, 1917, 7.

29 Ibid.

30 Hipp, *Poetry of Shell Shock*, 8.

31 *Hydra*, December, 1917, 9.

32 Owen, *Selected Letters*, 282.

33 Hipp, "By Degrees," 39-40.

34 Owen, *Selected Letters*, 291.

35 Owen, *Selected Letters*, 290; 289.

Nanoliposomal Nitroglycerin Exhibits Potent Anti-inflammatory Effects and Ameliorates Adverse Effects Associated with High-dose Nitroglycerin

Shane Eum, Soroush Ardekani, Kaustabh Ghosh

Department of Bioengineering

ABSTRACT

Nitroglycerin (NTG) markedly enhances nitric oxide (NO) bioavailability. However, its ability to mimic the anti-inflammatory properties of NO remains unknown. The goal of this study was to examine the effect of NTG on monocyte-endothelial cell (EC) adhesion and develop NTG nanoformulation to significantly improve its therapeutic efficacy.

ECs were treated with N5 - (1- iminoethyl)- L- ornithine (L-NIO) to reduce NO production and cause inflammation. The anti-inflammatory effect of NTG was determined by measurement of monocyte-EC adhesion. NTG nanoformulation was developed by encapsulating NTG within lipid nanoparticles whose size and cellular uptake were measured using dynamic light scattering and quantitative fluorescence microscopy, respectively.

NTG exhibited significant anti-inflammatory effects on NO-deficient ECs, as judged by recovery of endothelial NO, and inhibition of monocyte-EC adhesion. Importantly, nanoliposomal NTG (NTG-NL) had much greater anti-inflammatory effect than free NTG. Importantly, NTG-NL produced an approximately two orders of magnitude greater anti-inflammatory effect than free NTG. The superior therapeutic efficacy of NTG-NL was further evident when, unlike free NTG, higher doses of NTG-NL did not elicit monocyte-EC adhesion.

Our proof-of-concept studies reveal that NTG-NL exerts potent anti-inflammatory effects on NO-deficient ECs and ameliorates adverse effects associated with high-dose NTG treatment. These findings provide the rationale for detailed investigation of NTG-NL for potentially superior vascular normalization therapies.

Keywords: Nitroglycerin, Nanoliposome, Inflammation, Nitric Oxide, Endothelial Cells, Nanotherapeutic
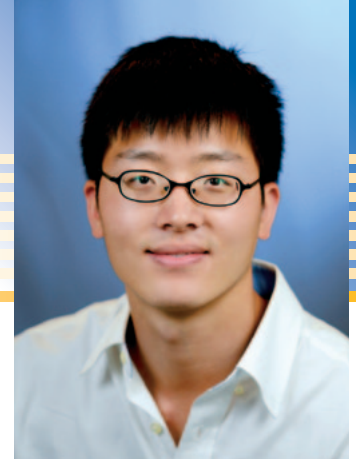
AUTHOR

Shane Eum

Department of Bioengineering

Shane Eum is a fourth year undergraduate student majoring in Bioengineering. He joined Kaustabh Ghosh's lab, working on a project to develop nanotechnological strategies to deliver therapeutic agents such that they preferentially home to and accumulate in specific injury or diseased sites in the body and promote in situ tissue normalization. He is a three-time recipient of the Hispanic Serving Institute (HSI) Undergraduate Research award. He plans to continue graduate studies in Bioengineering at UC Riverside.

FACULTY MENTOR

Kaustabh Ghosh

Department of Bioengineering

Kaustabh Ghosh., Ph.D. is an Assistant Professor of Bioengineering at the University of California, Riverside. He is an interdisciplinary biomedical scientist and engineer with a research interest in vascular inflammation, mechanobiology, and nanomedicine. Prior to joining UCR, he obtained his Ph.D. in Biomedical Engineering from SUNY, Stony Brook before pursuing a postdoctoral fellowship at the Vascular Biology Program at Children's Hospital & Harvard Medical School. He has published 21 peer-reviewed research articles in prominent journals including *PNAS, Nano Letters, JCI, and Science*.

Shane Eum

INTRODUCTION

Loss of endothelium-derived nitric oxide (NO), which prevents leukocyte-endothelial cell (EC) adhesion, is strongly implicated in chronic inflammation associated with debilitating cardiovascular conditions such as pulmonary arterial hypertension (PAH) [1], atherosclerosis [2], and diabetes [3]. Administration of nitrates/nitrites, which rapidly produce NO, is thus being explored as anti-inflammatory therapy [4, 5]. Since organic nitrates exert superior NO-dependent vasodilatory effects when compared with inorganic nitrates/nitrites [6], they likely also exhibit more potent anti-inflammatory effects.

Of the clinically used organic nitrates, nitroglycerin (NTG) holds particular promise because, in addition to spontaneously producing NO via mitochondrial aldehyde dehydrogenase (ALDH-2) [7], it also activates endothelial NO synthase (eNOS) [8, 9], the key NO-producing enzyme in ECs that is impaired in inflammatory cardiovascular conditions [10]. However, despite its potential anti-inflammatory effects, NTG presents a conundrum as long-term clinical use of current NTG formulations causes adverse effects such as impaired vasorelaxation in response to acute NTG treatment (NTG tolerance) [11, 12], which limit its therapeutic efficacy. Thus, new NTG delivery approaches are required to fully leverage the therapeutic potential of NTG.

The field of nanomedicine has enabled the development of nanomaterials (liposomes and polymeric nanoparticles) that can greatly improve drug delivery and therapeutic efficacy by simultaneously increasing drug half-life and reducing toxic side-effects [13, 14]. For instance, our previous work has shown that incorporation of genistein within polymeric nanoparticles improves its anti-inflammatory effect by over two orders of magnitude [15]. Thus, such a nanotherapeutic approach has the potential to ameliorate the adverse effects associated with contemporary high-dose NTG administration.

Here, we examined the hypothesis that NTG-derived NO can suppress endothelial activation during inflammation. Further, we developed the first nanoencapsulation approach for effective NTG delivery that amplifies its newly-identified anti-inflammatory effects while reducing endothelial dysfunction associated with high-dose NTG treatment.

METHODS

Cell Culture. Human microvascular endothelial cells (HMEC-1) were purchased from the Center for Disease Control (CDC) [15] and cultured tissue culture dishes coated with gelatin in growth medium composed of MCDB-131 (VWR International, USA) supplemented with 10% FBS (Fisherbrand, USA), 1x antimycotic/antibiotic mixture (Life Technologies, USA), 2 mM L-Glutamine (Invitrogen, USA), 1 µg/ml Hydrocortizone (Sigma Aldrich, USA) and 10 ng/ml huEGF (Millipore, USA). Human U937 monocytic cells were purchased from ATCC (Manassas, VA, USA) and cultured in suspension in growth medium composed of RPMI 1640 (Fisherbrand, USA) supplemented with 10 mM HEPES (Fisherbrand, USA), 10% FBS (Fisherbrand), 2 mM L-Glutamine (Invitrogen), 1 mM sodium pyruvate (Life Technologies, USA) antimycotic/antibiotic mixture (Life Technologies, USA) and 4.5 mg/ml glucose (Sigma Aldrich, USA).

Nanoparticle (NP) Formulation. To synthesize NTG-loaded nanoliposomes (NTG-NL), four lipid molecules viz. 1,2-di-(3,7,11,15-tetramethylhexadecanoyl)-sn-glycero-3-phosphocholine (DPhPC; Avanti Lipids, USA), cholesterol (Sigma Aldrich, USA), 1-hexadecanoyl-2-(9Z-octadecenoyl)-sn-glycero-3-phosphocholine (POPC; Avanti Lipids, USA), and 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-triethylammonium salt (Texas Red-DHPE; Invitrogen, USA) were dissolved in chloroform at a molar ratio of 6:2:2:0.2, respectively, and purged with Nitrogen (N2) to evaporate the organic solvent. Subsequently, the lipid cake was placed under vacuum for at least two hours prior to reconstituting in aqueous NTG (10% w/w of total lipid; Cerilliant, USA) or Fluorescein (1 mM; Sigma Aldrich, USA) solution to obtain a final 1 mg/ml drug- or dye-loaded liposome suspension. To obtain nano-scale NTG-NLs, these liposome suspensions underwent five freeze-thaw cycles in liquid N2 followed by eight extrusion cycles through a 100 nm polycarbonate membrane filter (Avanti Lipids, USA). Unincorporated NTG or fluorescein was discarded by spinning down

NANOLIPOSOMAL NITROGLYCERIN EXHIBITS POTENT ANTI-INFLAMMATORY EFFECTS AND AMELIORATES ADVERSE EFFECTS ASSOCIATED WITH HIGH-DOSE NITROGLYCERIN

Shane Eum

NTG-NLs at 60,000 rcf for two hours at 4°C using an ultracentrifuge (Beckman Coulter, USA) and decanting the supernatant. The final NTG-NL pellet was suspended at 1 mg/ml in water and stored at 4oC until use.

Nanoliposome Size Characterization. Blank NL and NTG-NL suspensions were prepared at 0.5 mg/ml in distilled water and size distribution measured by dynamic light scattering (DLS) using a Delsa Nano C Particle Analyzer (Beckman Coulter, USA). Microsoft Excel and Origin Pro software were used to acquire and analyze the data.

Nanoliposome (NL) Uptake. To determine the rate of NL uptake by ECs, Texas Red®-labeled NLs were diluted in EC culture medium at 5 μg/ml and added to ECs for 5, 15, 30 or 60 min at 37oC. After treatment, non-internalized NLs were removed by rinsing ECs twice with PBS, following by culturing ECs in phenol-red free MEM media (Life Technologies, USA) supplemented with 2 mM L-Glutamine and 10% FBS and measurement of fluorescence intensity by Wallac 1420 Victor2 fluorescent microplate plate reader (Perkin Elmer, USA). To determine % NL uptake, fluorescence intensity of NL-treated ECs was divided by the intensity obtained from unrinsed samples.

Monocyte Adhesion Assay. To examine the effects of NTG on monocyte-EC adhesion, confluent EC monolayers were either serum-starved (MCDB-131, 2.5% FBS, and 1X antibiotic/antimycotic supplement) overnight and treated with treated for 4 hr or overnight with 5 mM N5 - (1- iminoethyl)- L- ornithine (L-NIO; selective eNOS inhibitor; Cayman Chemical, MI, USA) ± varying doses of NTG (0, 0.06, 0.2, 1 or 5 μM; Cambridge Isotope, MA) in regular medium, followed by addition of DAPI-labeled U937 monocytic cells (altered for better image contrast) at a density of 130,000 cells/cm2. After 30 min of monocyte-EC interaction at 37oC, monocyte suspension was removed and the EC monolayers gently rinsed twice with PBS (to remove unbound monocytes) prior to fixation in 1% paraformaldehyde (PFA; Electron Microscopy Sciences, USA). Fluorescent images (10 per condition) of labeled U937 cells were then acquired using a Nikon Eclipse Ti microscope (Nikon, Japan) fitted with a Nikon Digital Sight DS-Qi1Mc camera and the number of adherent monocytes was counted using ImageJ software (NIH). For experiments

involving NLs, ECs were incubated with 5 μg/ml of blank or 10% (w/w) NTG-loaded nanoparticles (NTG-NL) for 30 minutes at 37oC, rinsed with PBS to remove excess NLs, and cultured overnight prior to addition of fluorescently-labeled U937 cells (as described above).

Statistics. All data were obtained from multiple replicates (as described in the appropriate sections) and expressed as mean ± standard error of mean (SEM). Statistical significance was determined using analysis of variance (ANOVA; InStat; Graphpad Software Inc.) followed by a Tukey multiple comparison post-hoc analysis. Results demonstrating significance were represented as *$p < 0.05$, **$p < 0.01$, or ***$p < 0.001$.

RESULTS

NTG Exerts Anti-inflammatory Effects on Activated ECs

Since NTG enhances endothelial NO bioavailability through both spontaneous biotransformation and eNOS activation [7, 8], we asked whether NTG could mimic the anti-inflammatory property of NO. To address this question, EC monolayers were treated with L-NIO (5 mM), which cause eNOS/NO deficiency [8, 16] and thereby enhance monocyte-EC adhesion both *in vitro* and in pathological conditions in vivo [1, 10]. Images of fluorescently-labeled adherent monocytes and their quantification revealed that addition of NTG to LNIO-treated ECs produces a dose-dependent inhibition of U937 monocytic cell adhesion to ECs (Figure 1A and 1B), with the inhibition being significant ($p < 0.01$) at 5 μM dose where U937 cell adhesion was comparable with that on untreated ECs.

Synthesis and Physicochemical Characterization of Nanoliposomal NTG (NTG-NL)

Despite important therapeutic implications of the anti-inflammatory effects of NTG, its systemic delivery using conventional high-dose formulations causes adverse effects in the form of enhanced mitochondrial superoxide production, thereby leading to endothelial dysfunction (NTG tolerance) [11, 12]. To address this issue, we employed the principles of nanotechnology to incorporate NTG within nanoparticles (NPs) as they are known to significantly improve drug efficacy [14, 15].

NANOLIPOSOMAL NITROGLYCERIN EXHIBITS POTENT ANTI-INFLAMMATORY EFFECTS AND AMELIORATES ADVERSE EFFECTS ASSOCIATED WITH HIGH-DOSE NITROGLYCERIN

Shane Eum
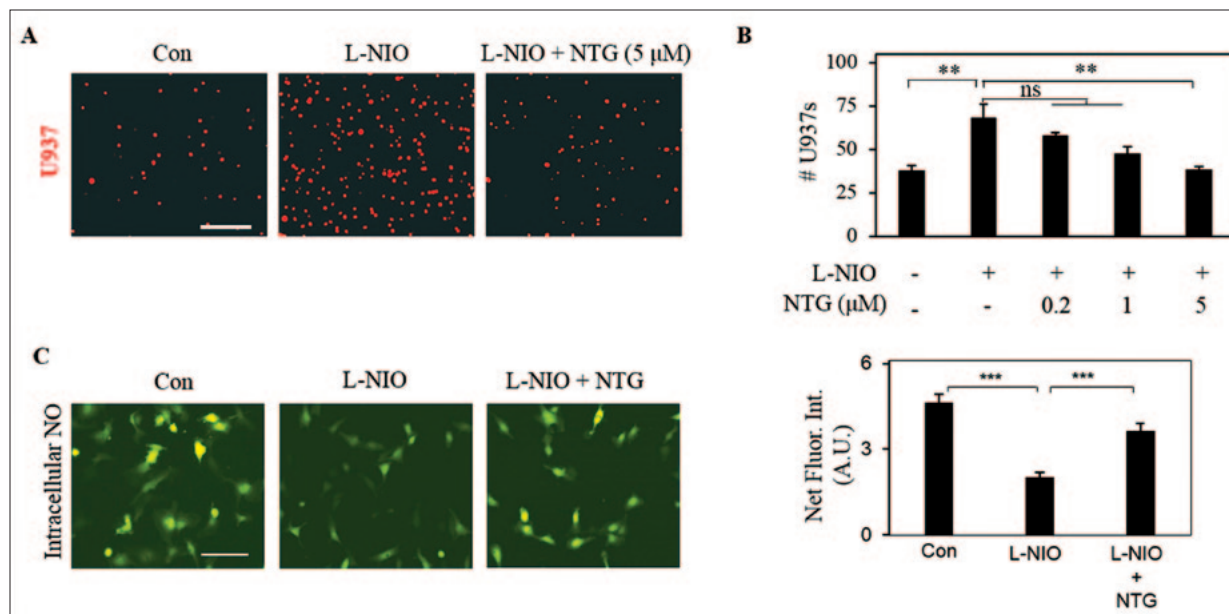
Figure 1. NTG Exerts Anti-inflammatory Effects on Activated ECs. NTG produces dose-dependent inhibition of DAPI-labeled U937 monocytic cell adhesion to L-NIO-treated ECs, as shown in the fluorescence images (converted to red for better image contrast) (A) and quantified in the bar graph (n = 10 fields of view) (B) **,$p<0.01$; ***,$p<0.001$. Data are expressed as mean ± SEM. Scale bar: 200 µM. (C) Fluorescent images of ECs labeled with NO-sensitive dye (DAF-FM diacetate) and subsequent image analysis (bar graph; n = at least 30 cells) confirms that NTG-mediated increase in NO results from greater endothelial NO synthesis. Scale bar: 25 µm

NPs were made from a combination of four lipids (DPhPC, POPC, Cholesterol, and DHPE-Texas Red). This building block was chosen because the NTG molecule contains both hydrophilic and hydrophobic residues. Thus, we reasoned that if NTG exhibits predominantly hydrophobic characteristics, it would preferentially incorporate within the lipid bilayer of the lipid nanoparticle (nanoliposomes; NL); if it exhibits greater hydrophilicity, it would incorporate within the hydrophilic core of the lipid (Figure 2A).
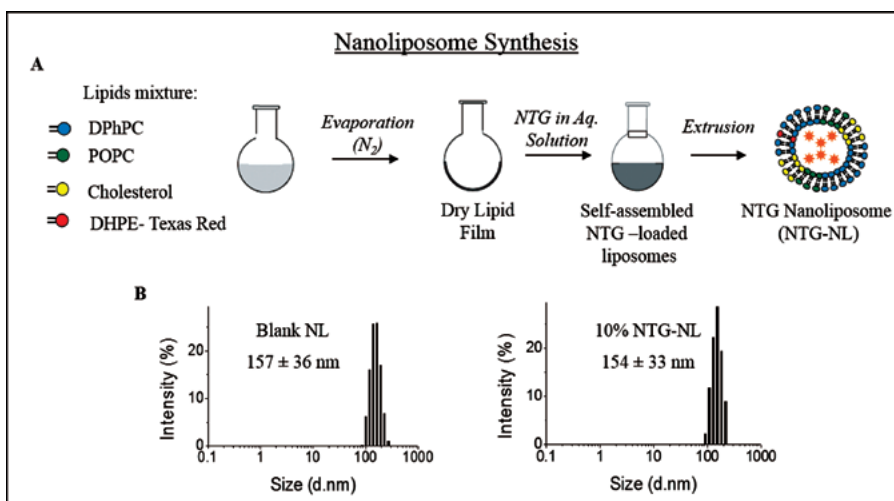
Figure 2. Synthesis and Physicochemical Characterization of Nanoliposomal NTG (NTG-NL). (A) For incorporation within nanoliposomes (NLs), NTG was mixed with four lipids viz. DPhPC, POPC, Cholesterol, and DHPE-Texas Red, which self-assemble to form nanoliposomes in an aqueous solution [24]. (B) Dynamic Light Scattering (DLS) analysis reveals that both blank and NTG-loaded NLs exhibit similar diameter (~155 nm). Data are expressed as mean ± Std Dev.

NANOLIPOSOMAL NITROGLYCERIN EXHIBITS POTENT ANTI-INFLAMMATORY EFFECTS AND AMELIORATES ADVERSE EFFECTS ASSOCIATED WITH HIGH-DOSE NITROGLYCERIN

Shane Eum
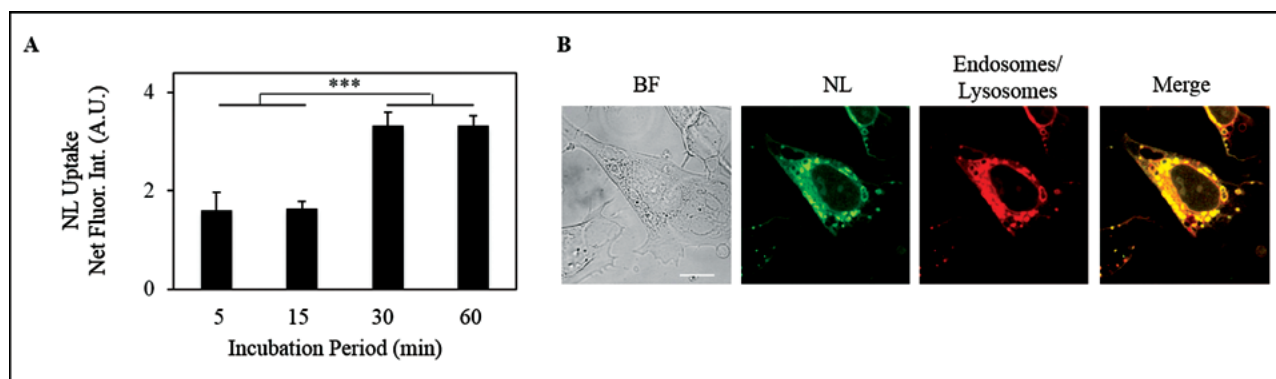
Figure 3. Cellular Uptake of Nanoliposomes. (A) Spectrophotometer measurements of internalized fluorescently-labeled nanoliposomes (NL) reveal time-dependent uptake of NLs by cultured ECs (n = 5 replicates per condition). (B) Fluorescent images of internalized NLs indicate strong colocalization with LysoTracker Red™-labeled endocytic vesicles (lysosomes and endosomes). Scale bar: 10 μm. ***, p<0.001. Data are expressed as mean ± SEM.

The size distribution profile of NLs, obtained using dynamic light scattering (DLS), revealed an average diameter of 157 ± 36 nm and 154 ± 33 nm for blank and NTG-NL, respectively (Figure 2B).

Cellular Uptake of Nanoliposomes

Following NL synthesis, we examined their uptake by cultured ECs. Fluorescein-loaded NLs (5 μg/ml) were added to ECs for 5, 15, 30, or 60 min prior to fixation and imaging. Quantification of intracellular fluorescence intensity measurements revealed that nanoliposomal uptake peaked at approximately 30 min, followed by a plateau between 30-60 min (Figure 3A). These internalized NLs expectedly localized within the acidic endocytic organelles viz. lysosomes and endosomes that line the perinuclear region (Figure 3B). Based on these observations of nanoliposomal uptake, all subsequent in vitro cell functional studies were performed following 30 min treatment with a 5 μg/ml dose of NL.

NTG-NL Exerts Superior Anti-inflammatory Effects and Ameliorates High-dose Endothelial Dysfunction

For NTG-NL to be truly effective as an anti-inflammatory therapy, it is essential that blank NLs exert no inflammatory effects. To confirm this, we analyzed monocyte adhesion to ECs treated with blank NLs. Quantification of adherent U937 cells revealed that monocyte adhesion to blank NL-treated ECs is comparable to that seen on untreated ECs (Figure 4A). Further, treatment of ECs with blank NLs failed to suppress L-NIO-induced increase in U937 cell-EC adhesion (Figure 4A). These data clearly indicate that blank NLs are totally inert to ECs.

Nanoparticles are known to enhance drug efficacy by simultaneously increasing drug half-life and facilitating rapid cellular uptake [13-15]. Thus, we asked whether the internalized NTG-NLs could improve the anti-inflammatory effect of incorporated NTG. Our studies indicate that addition of NTG-NL (5 μg/ml) to L-NIO-treated ECs produced a significant inhibition (52%; p<0.001) of U937 cell adhesion to ECs, with the number of adherent monocytes returning to the levels seen on untreated ECs (Figure 4B). This reduction in monocyte-EC adhesion by NTG-NL was comparable to the anti-inflammatory effect produced by a 5 μM dose of free NTG. Determination of the total amount of NTG delivered through nanoliposomal formulation revealed that NTG-NL produced its potent anti-inflammatory effect at 0.06 μM, which is ~85-fold less than the effective free NTG dose (5 μM). In other words, NTG-NL was found to be ~85-fold more effective than free NTG in suppressing endothelial activation. That this remarkable increase in therapeutic efficacy resulted primarily from nanoformulation of NTG was confirmed by the observation that an equivalent amount (0.06 μM) of free NTG failed to produce a significant anti-inflammatory effect (Figure 4B).

NANOLIPOSOMAL NITROGLYCERIN EXHIBITS POTENT ANTI-INFLAMMATORY EFFECTS AND AMELIORATES ADVERSE EFFECTS ASSOCIATED WITH HIGH-DOSE NITROGLYCERIN

Shane Eum
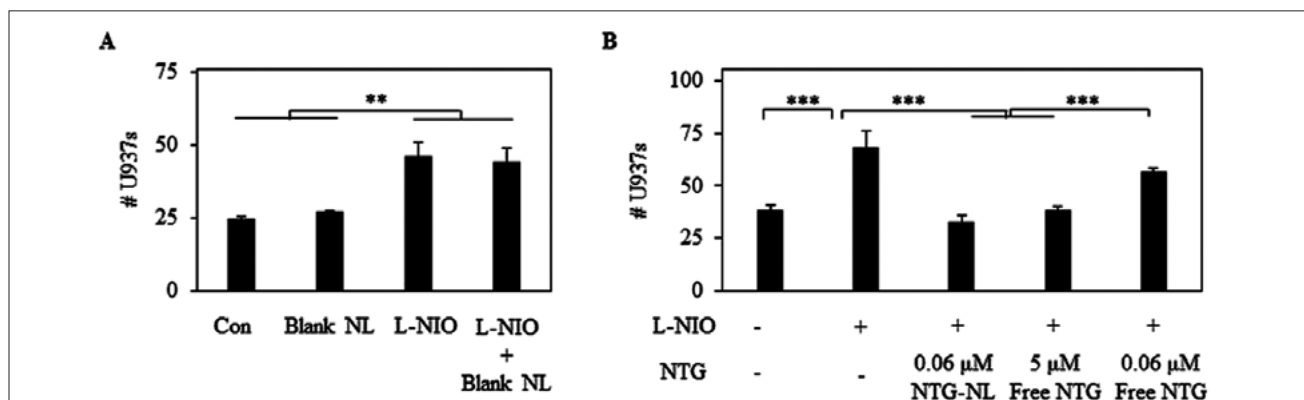
Figure 4. NTG-NL Exerts Superior Anti-inflammatory Effects. (A) Blank NLs are inert to ECs as cells treated with blank NLs exhibit neither an increase in U937 cell adhesion (with respect to control) nor a decrease in LNIO-induced U937 cell adhesion (n = 10 fields of view). (B) Addition of 5 μg/ml NTG-NL (≡ 0.06 μM NTG) to L-NIO-treated ECs significantly inhibits U937 cell-EC adhesion, which is comparable to the inhibition produced by an ~85-fold greater dose of free NTG (5 μM). Free NTG dose of 0.06 μM does not produce a significant anti-inflammatory effect. (n = 10 fields of view). **, p<0.01; ***, p<0.001. Data are expressed as mean ± SEM.

DISCUSSION

This study demonstrates a proof-of-principle for a new nanoliposomal NTG formulation that amplifies the newly-identified anti-inflammatory properties of NTG while significantly ameliorating the adverse effects (i.e. NTG tolerance) associated with conventional NTG therapy. NTG is the most commonly used organic nitrate in the clinic where it is intended to mimic the vasodilatory effects of endothelium-derived NO. Since endothelial NO also exhibits potent anti-inflammatory effects, here we asked whether NTG can suppress leukocyte-EC adhesion.

Our findings reveal that NTG strongly inhibits monocyte adhesion to NO-deficient ECs. Although inorganic nitrites have been shown to exert anti-inflammatory effects [4], to our knowledge, this is the first report indicating that NTG also exhibits similar properties. Coupled with previous findings that (1) NTG activates eNOS [8, 9], the major NO-producing enzyme in ECs that is impaired in inflammatory conditions such as PAH[1] and diabetes [3], and (2) NTG mimics the anti-coagulating properties of NO to prevent inflammation-associated hypercoagulopathy [17], the current findings provide further rationale for investigating the use of NTG for anti-inflammatory therapy.

To improve the benefit profile of NTG therapies, we leveraged the principles of nanotechnology to develop a new nanoliposomal NTG formulation (NTG-NL) that demonstrates a remarkable ~85-fold increase in therapeutic (anti-inflammatory) effect. Such tremendous increase in drug efficacy is the hallmark of nanocarrier-mediated drug delivery, which is known to increase drug half-life and promote rapid cellular uptake and bioavailability of encapsulated drugs [14, 15]. Importantly, the significant enhancement in NTG-NL bioactivity and resultant lowering of the effective therapeutic dose meant that, unlike free NTG, NTG-NL did not elicit any tolerance in the form of impaired anti-inflammatory effect even at very high (20-fold greater) doses. These findings implicate NLs as an effective NTG delivery system that has the potential to address the adverse effects associated with current NTG therapies.

Liposomes are commonly used as drug carriers in pharmaceutical industry and the size (~150 nm dia.) of NTG-NL is suitable for use as long-circulating nanoparticles [14, 21]. Thus, the proof-of-concept studies described here set the stage for the development of site-targeting NTG nanotherapeutics that can further improve the efficacy of nanoliposomal NTG by simultaneously increasing drug half-life and reducing undesirable off-target effects. As we and others have previously shown [15, 22], such site-targeting can be accomplished by tethering unique targeting moieties (peptides, aptamers or antibodies) [14, 15] on the nanoparticle surface. By addressing the

NANOLIPOSOMAL NITROGLYCERIN EXHIBITS POTENT ANTI-INFLAMMATORY EFFECTS AND AMELIORATES ADVERSE EFFECTS ASSOCIATED WITH HIGH-DOSE NITROGLYCERIN

Shane Eum

adverse effects associated with conventional high-dose NTG formulations, such smart nanomedicine approaches may enable us to simultaneously leverage the newly-identified anti-inflammatory and well-known vasodilatory properties of NTG for superior management of PAH that is characterized by both severe vasoconstriction and chronic pulmonary arterial inflammation [23].
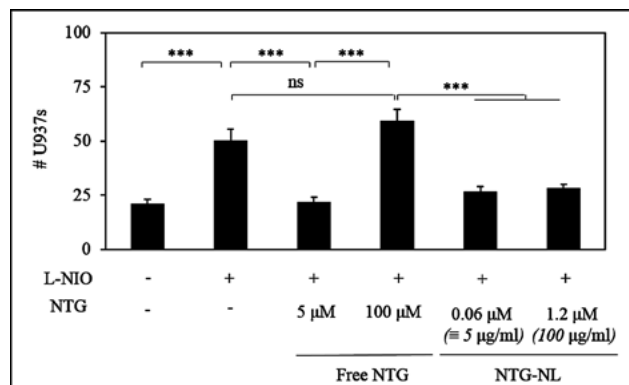
Figure 5. NTG-NL Prevents Endothelial Dysfunction Associated with High NTG Dose. *The high dose of free NTG fails to suppress U937 monocytic cell adhesion to L-NIO-treated ECs (n = 10 fields of view). NTG-NL continues to exert potent anti-inflammatory effect on L-NIO-treated ECs at the 20-fold higher dose (n = 10 fields of view). ***, p<0.001. Data are expressed as mean ± SEM.*

REFERENCES

[1] Rabinovitch M. Molecular pathogenesis of pulmonary arterial hypertension. J Clin Invest. 2012;122:4306-13.

[2] Tousoulis D, Kampoli AM, Tentolouris C, Papageorgiou N, Stefanadis C. The role of nitric oxide on endothelial function. Curr Vasc Pharmacol. 2012;10:4-18.

[3] Zhang YX, Janssens SP, Wingler K, Schmidt HHHW, Moens AL. Modulating endothelial nitric oxide synthase: a new cardiovascular therapeutic strategy. Am J Physiol-Heart C. 2011;301:H634-H46.

[4] Stokes KY, Dugas TR, Tang YP, Garg H, Guidry E, Bryan NS. Dietary nitrite prevents hypercholesterolemic microvascular inflammation and reverses endothelial dysfunction. Am J Physiol-Heart C. 2009;296:H1281-H8.

[5] Herman AG, Moncada S. Therapeutic potential of nitric oxide donors in the prevention and treatment of atherosclerosis. Eur Heart J. 2005;26:1945-55.

[6] Omar SA, Artime E, Webb AJ. A comparison of organic and inorganic nitrates/nitrites. Nitric Oxide. 2012;26:229-40.

[7] Chen Z, Zhang J, Stamler JS. Identification of the enzymatic mechanism of nitroglycerin bioactivation. Proc Natl Acad Sci U S A. 2002;99:8306-11.

[8] Bonini MG, Stadler K, Silva SO, Corbett J, Dore M, Petranka J, et al. Constitutive nitric oxide synthase activation is a significant route for nitroglycerin-mediated vasodilation. Proc Natl Acad Sci U S A. 2008;105:8569-74.

[9] Mao M, Sudhahar V, Ansenberger-Fricano K, Fernandes DC, Tanaka LY, Fukai T, et al. Nitroglycerin drives endothelial nitric oxide synthase activation via the phosphatidylinositol 3-kinase/protein kinase B pathway. Free Radic Biol Med. 2012;52:427-35.

[10] Zhang Y, Janssens SP, Wingler K, Schmidt HH, Moens AL. Modulating endothelial nitric oxide synthase: a new cardiovascular therapeutic strategy. Am J Physiol Heart Circ Physiol. 2011;301:H634-46.

[11] Daiber A, Oelze M, Coldewey M, Bachschmid M, Wenzel P, Sydow K, et al. Oxidative stress and mitochondrial aldehyde dehydrogenase activity: a comparison of pentaerythritol tetranitrate with other organic nitrates. Molecular pharmacology. 2004;66:1372-82.

[12] Sydow K, Daiber A, Oelze M, Chen Z, August M, Wendt M, et al. Central role of mitochondrial aldehyde dehydrogenase and reactive oxygen species in nitroglycerin tolerance and cross-tolerance. J Clin Invest. 2004;113:482-9.

[13] Farokhzad OC, Langer R. Impact of nanotechnology on drug delivery. ACS nano. 2009;3:16-20.

[14] Shi J, Votruba AR, Farokhzad OC, Langer R. Nanotechnology in drug delivery and tissue engineering: from discovery to applications. Nano Lett. 2010;10:3223-30.

NANOLIPOSOMAL NITROGLYCERIN EXHIBITS POTENT ANTI-INFLAMMATORY EFFECTS AND AMELIORATES ADVERSE EFFECTS ASSOCIATED WITH HIGH-DOSE NITROGLYCERIN

Shane Eum

[15] Ghosh K, Kanapathipillai M, Korin N, McCarthy JR, Ingber DE. Polymeric nanomaterials for islet targeting and immunotherapeutic delivery. Nano Lett. 2012;12:203-8.

[16] Yoshizumi M, Perrella MA, Burnett JC, Jr., Lee ME. Tumor necrosis factor downregulates an endothelial nitric oxide synthase mRNA by shortening its half-life. Circulation research. 1993;73:205-9.

[17] Cotechini T, Othman M, Graham CH. Nitroglycerin prevents coagulopathies and foetal death associated with abnormal maternal inflammation in rats. Thromb Haemost. 2012;107:864-74.

[18] Nie SD, Hu CP, Chen YR, Wang S, Deng HW, Li YJ. Reversal of tolerance to nitroglycerin with vinpocetine: a role of calcitonin gene-related peptide. Int J Cardiol. 2008;125:436-8.

[19] Knorr M, Hausding M, Kroller-Schuhmacher S, Steven S, Oelze M, Heeren T, et al. Nitroglycerin-induced endothelial dysfunction and tolerance involve adverse phosphorylation and S-Glutathionylation of endothelial nitric oxide synthase: beneficial effects of therapy with the AT1 receptor blocker telmisartan. Arteriosclerosis, thrombosis, and vascular biology. 2011;31:2223-31.

[20] Perche F, Torchilin VP. Recent trends in multifunctional liposomal nanocarriers for enhanced tumor targeting. Journal of drug delivery. 2013;2013:705265.

[21] Immordino ML, Dosio F, Cattel L. Stealth liposomes: review of the basic science, rationale, and clinical applications, existing and potential. Int J Nanomedicine. 2006;1:297-315.

[22] Kolhar P, Anselmo AC, Gupta V, Pant K, Prabhakarpandian B, Ruoslahti E, et al. Using shape effects to target antibody-coated nanoparticles to lung and brain endothelium. Proc Natl Acad Sci U S A. 2013;110:10753-8.

[23] Voelkel NF, Gomez-Arroyo J, Abbate A, Bogaard HJ, Nicolls MR. Pathobiology of pulmonary arterial hypertension and right ventricular failure. Eur Respir J. 2012;40:1555-65.

[24] Avanti Polar Lipids (2015) Preparation of Liposomes. Retrieved from http://www.avantilipids.com/index.php?option=com_content&view=article&id=1384&Itemid=372.

Linear and Cyclic Constructions of Time in *Sir Gawain and the Green Knight*

Sarah Folk, John Ganim

Department of English

ABSTRACT

This paper explores the tensions in the medieval long poem *Sir Gawain and the Green Knight* between Christian rectilinear teleological and pagan cyclic temporal movements, as defined and discussed in Frank Kermode's *The Sense of an Ending.* I explicate the poem's intended affiliation with teleological Christian viewpoints while delving into the deep-seated conflicts of appropriating pagan Arthurian folklore into nationalized British Christian legend. I further define cyclic temporal movement and examine moments in the poem in which the two forms of temporal movement are contrasted or juxtaposed. I discuss the impossibility of attaining "perfect Christian knighthood," and I consider matters of exchange in the poem and their implications regarding ideological perspective.

Keywords: time, movement, linear, cyclic, Christian, pagan, feminine, virtue, chivalry, knight.

FACULTY MENTOR

John Ganim

Professor of English

Distinguished Professor John Ganim is the author of four books and has published over fifty articles on medieval literature and on how the medieval is engaged in film, architecture and political theory. He has served as President of the New Chaucer Society and is currently Vice-President of the Pacific Ancient and Modern Language Association. He was a Guggenheim Fellow and recently received the Distinguished Humanist Research Award from the College of Arts, Humanities and Social Sciences at UCR.

AUTHOR

Sarah Folk

Department of English

Sarah Folk is a fourth year student majoring in English. She has worked with Professor John Ganim since 2013 and is interested in the various intersections and resonances of medieval and Renaissance literature with modern canonical forms. Her essay, "The Recovery of the Ideal Parents in *The Winter's Tale* and *The Tempest*," won the 2014 UCR Undergraduate Student Essay Contest. She would like to thank her faculty mentor and her professors for their support and encouragement, which have been utterly indispensable to her in the course of her undergraduate studies.

Sarah Folk

In *Sir Gawain and the Green Knight*, the poet deals with conflicting conceptions of time, which arise from the historical appropriation of subversive pagan Arthurian folklore and its integration into traditional nationalist Christian mythology. The linear, teleological construction of time espoused by proponents of Christian doctrine is one which gives meaning and purpose to men's otherwise menial and inconsequential existences; it directly conflicts with the ancient perception of time as being cyclical. This cyclic understanding originated with predominantly agrarian societies, which were utterly dependent on the seasons for their livelihood and consequently worshipped the pagan deities who controlled those seasons. Sir Gawain, fastidious and ever concerned with his own perfection, is the poet's representative of Christian ideals, and his journey toward impending death is an allegory for that teleological temporal structure. But symbols of cyclical time and the pagan heritage with which it is associated appear throughout the poem, especially toward its resolution, questioning the supremacy of Christianity and the completeness of its adoption. The poet, likely a Christian himself, uses the conflicting representations of time within *Sir Gawain and the Green Knight* to demonstrate the flaws inherent to the integration of pagan legend into Christian mythology, suggesting that it is not nearly as seamless as might be intimated by society and contemporary chivalric discourse.

To fathom the complexities of the temporal conflicts with which the *Gawain*-poet deals, knowledge of *Gawain*'s plot is requisite. In this tale, Arthur and his Round Table are celebrating Christmastide as the New Year dawns. Before the feast begins, an enormous knight rides into the hall, shocking the assembled knights and ladies with his appearance: he is entirely green. His skin, hair, and clothes are green. Even his horse is green. This fellow, aptly named the "Green Knight" for the remainder of the text, proposes a Christmas game to Arthur's court. He offers any brave soul an opportunity to strike one blow and cut off his head, provided that he who does the deed will promise him the same chance in a year and a day. Sir Gawain, Arthur's nephew, reluctantly accepts the challenge; he wields the ax and beheads the Green Knight in one stroke, seemingly ending his life. But the decapitated body simply picks up the bleeding head, which speaks to remind Gawain of the promise he must fulfill in a year's time, and rides off.

When the appointed time nears, Gawain dons armor and shield and sets forth in search of the Green Knight's chapel. After a long journey, he begins to despair of ever finding the Knight to honor his oath. At last, he reaches a castle whose host, Sir Bertilak, warmly welcomes him and entreats him to stay awhile for the Yuletide festivities, revealing that the Green Chapel is near, so his search is over. Gawain gladly accepts. During his stay, Lady Bertilak, his host's wife, tries to seduce Gawain three times. He withstands her advances, though his resolve wavers noticeably by the third try. Eventually, Gawain accepts as a gift from her a green girdle said to bear a magical quality: the person wearing it cannot be physically slain. He fails to relinquish the gift to his host, though he had earlier sworn to do so. With the girdle wound twice about his waist, Gawain faces the Green Knight at his chapel and braces himself for execution. The Knight feints twice and, on the third stroke, delivers a glancing blow, giving Gawain but a small bleeding scratch. Gawain, believing he has survived due to the girdle, is shocked and ashamed to discover that the Green Knight is actually Sir Bertilak in disguise and that his wife's advances and gifting of the girdle constituted tests of Gawain's virtue, tests conducted with her husband's knowledge. Indeed, the entire plot is a contrivance of Morgan le Fay, the sorceress and half-sister of Arthur, who uses her enchantment to provide Bertilak with his green guise and supernatural ability to survive the initial beheading. Gawain then returns to court to tell of his quest and failure. At the poem's end, Arthur comforts him, decreeing that all Table knights will wear a green sash in honor of Gawain.

The *Gawain*-poet's tale may be viewed through the lens of Frank Kermode's exposition of apocalypse, *The Sense of an Ending*. His text fails to discuss *Gawain* at all—surprising, since his model of time lends itself so handsomely to analysis thereof. He says, "men die because they cannot join the beginning and the end" (4). Man cannot remember the beginning (because he was not yet born) and cannot see the end (because it has not yet come). Failure to perceive beginning and end gives rise to despair and anxiety over the apparent vanity and purposelessness of men's lives (3-4). What do men create to console themselves? Kermode posits that the historically near-universal embrace of creationism or theistic worship imbues man's life with

purpose, mitigating his pain and giving meaning to his otherwise futile, purposeless, and random existence. He states that the genre of fiction arises from this desire to make tolerable the "moment between beginning and end," to find meaning (4). Fiction is the imagining of significance in the "unremembered but imaginable events," the construction of beginning and end (4). Theistic belief and the practice of storytelling both emanate from man's desire to create significance and purpose in his life.

Kermode then marks a distinction between linear and cyclic temporal movement, crucial to discerning the *Gawain*-poet's view. As said earlier, man is concerned with apocalypse because perceiving or imagining the end gives life significance. The resultant apocalyptic thought, man's obsession with the end, "belongs to rectilinear rather than cyclical views of the world" (Kermode 5). Christian theology is notably teleological, linear; the Bible progresses from Genesis ('origin' or 'beginning') to its end, Revelation ('apocalypse'), culminating in the attainment of the City of God. Kermode expounds this linear movement of time in detail but says relatively little about the cyclic; this paper will address that deficiency. Under cyclic temporal movement, for particular events, it is the time of year, the progress of the cycle, which counts, not the time betwixt events. I contend that this construct of time is expressed in and mainly derived from agrarian culture and necessity. The time between planting and harvest is, in a sense, immaterial. Seed is sown in the proper season, the right moment in the ritual. If sown at the wrong cyclic point, it cannot exhibit proper growth or rich yield, no matter the time betwixt sowing and harvest. This bears immediate relevance to men's existences; their living depends on this interpretation of time. It ushers in the worship of the pagan deities controlling the seasons and contrasts with linear temporal structure, which gives rise to the visions and imaginings of apocalypse. Returning to Kermode: "Virgil, describing the progress of Aeneas from the broken city of Troy to a Rome standing for empire without end, is closer to our traditional apocalyptic, [so] his *imperium* has been incorporated into Western apocalyptic as a type of the City of God" (5). Events occurring to Aeneas, Virgil's hero, "all exist under the shadow of the end," the City of God so prevalent in Christian doctrine (5).

It is of note that Kermode should mention Virgil's Aeneas and his move from desolated Troy to ascendant Rome, since *Sir Gawain and the Green Knight* opens with this very legend:

> Since the siege and the assault was ceased at Troy,
> The walls breached and burnt down to brands and ashes,
> The knight that had knotted the nets of deceit
> Was impeached for his perfidy, proven most true,
> It was high-born Aeneas and his haughty race
> That since prevailed over provinces, and proudly reigned
> Over well-nigh all the wealth of the West Isles.
> Great Romulus to Rome repairs in haste;[1] (*Gawain* 1-8)

The poet's intended affiliation with teleological temporal movement declares itself here; *Gawain* could not have commenced in a more fitting manner. (This renders exceptionally odd the fact that Kermode did not even mention *Gawain*.) Instead of relating events to their moment in the progression of a cycle, the happenings of the opening and, by extension, of the entire poem occur "[s]ince the siege and the assault was ceased at Troy" (1). All other events, like the foundational stories which ensue, happen after a particular event, Troy's destruction, has "ceased." The events are related and measured against each other, affirming Kermode's theory of linear time. Nothing occurs until the siege of Troy ceases. This mythic siege assumes the role of fictive beginning, the unremembered and imagined event to which men must relate other events to derive significance.

The siege of Troy is invested with the role of the beginning; nothing of significance takes place before it. Once it falls, however, other events may occur in rapid succession. The imagined beginning, Troy, is first in a line of standing dominoes; its toppling allows all other dominoes to tip, inciting ensuing founding legends. Aeneas and kin reign, accruing wealth; Romulus "repairs in haste" to build Rome (5-9). Founding myths of other regions like Tuscany and Lombardy also appear in these lines, including this: "And far over the French Sea, Felix Brutus / On many broad hills and high Britain he sets, / most fair" (13-5). Here, mythic Brutus builds Great Britain. The poem then launches into a depiction of Arthur and his court to open its fantastical plot in earnest. But the story of Gawain's encounter with

the Green Knight could not possibly occur without its being firmly entrenched and mythologized into nationalist British legend. By starting with Troy and telling the mythological founding of one kingdom after another, the poet correlates Arthurian legend with the birth and growth of Western civilization, reiterating that largely fictional history told by Geoffrey of Monmouth detailing the kings of Britain. This legendary history appropriates Arthur (who, if he existed, was most likely a native Celtic pagan ruler leading the defense against invaders and colonizers like the aforementioned Brutus) as an Anglo-Saxon hero. The poet thus follows Geoffrey's lead to interpolate the pagan Arthur into Christian British legend and make him a natural successor of Brutus, who would have been his foe in real life. In this way, Britain appropriates native culture and legend, Christianizing it and turning a native rebel who upholds a cyclic temporal movement into the most iconic British king of all time, in legend or reality. The poet bolsters this mythic interpolation and appropriation by instilling teleological time movement into the tale, making Arthur's rule in Britain the inevitable result of the siege which, per *Gawain*, initiates all modern notions of Western civilization. Arthur's court and the events which transpire therein are thus imbued with significance via relation to that imagined linear beginning at Troy.

Among "British kings," Arthur is "counted most courteous of all" (25-6). Note that his foremost trait is courtesy, rather than valor, honor, or another of his usual peerless virtues. At the time of *Gawain*, Arthur's court is still in its spring, its youth. Thus, the primary descriptor of this legendary king and interpolated successor of Brutus is that he is the "most courteous." The word *courteous* connotes not only the meaning of courtesy and politeness but also the courtier system, courtly love, courtship, and chivalry. *Courteous* thus suggests the primary conflict raised by appropriating Arthurian legend into Christian myth, a conflict this paper will now scrutinize.

Sir Gawain is the model of Christian perfection and virtue, and he is also the consummate knight, famed the world over for his chivalry and skill in the art of beautiful speech and courtly love. But the practice of courtly love is antithetical to Christian virtue, a paradox which the poet highlights in most amusing fashion through Gawain's bedroom scenes with Lady Bertilak, his host's wife. Gawain's notion of identity is inextricably linked to his projection of perfection, and when she accuses him of being an impostor, he anxiously and eagerly inquires as to the reason:

> "But our guest is not Gawain—forgot is that thought."
> "How so?" said the other, and asks in some haste,
> For he feared he had been at fault in the forms of his speech.
> But she held up her hand, and made answer thus:
> "So good a knight as Gawain is given out to be,
> And the model of fair demeanor and manners pure,
> Had he lain so long at a lady's side,
> Would have claimed a kiss, by his courtesy," (1293-1300)

Gawain, obsessed with the perfectness of his manners and deportment, seeks always to embody the symbol of Christian virtue displayed on his shield, "the pentangle portrayed in purest gold" (620). Here, Gawain finds himself in a quandary. If he does not play the lover to Lady Bertilak, his perfect courtesy and chivalric knighthood is in question due to his failure to perform courtly love. But if he acts on his reputation as the utmost chivalric and courtly knight, he dishonors his shield and loses his perfect Christian virtue. Gawain suffers an identity crisis. Perfect knighthood and chivalry are, at that bed, mutually exclusive with Christian virtue and the perfect morality it demands. But Gawain has inexplicably been able to foster both these reputations simultaneously, projecting both images of perfection so well that tales of his fame and dual perfection outstrip his actual personage. Bertilak's noble guests, upon discovering that the man arrived in their midst is Gawain, are overjoyed and expect much of their famed visitor, evidenced by their praises of him:

> Each said solemnly aside to his brother,
> "Now displays of deportment shall dazzle our eyes
> And the polished pearls of impeccable speech;
> The high art of eloquence is ours to pursue
> Since the father of fine manners is found in our midst.
> Great is God's grace, and goodly indeed,
> That a guest such as Gawain he guides to us here
> When men sit and sing of their Savior's birth
>> in view.
>> With command of manners pure
>> He shall each heart imbue;
>> Who shares his converse, sure,
>> Shall learn love's language true." (915-27)

The nobles rejoice that at Christmastime, the day of Christ's birth, Gawain has arrived to teach them pure customs, fine manners, deportment, and eloquent, impeccable speech. But mentioned in almost the same breath as Christianity is the iterated requirement of chivalry and courtly love: because Gawain is such a perfect knight, they seek to learn "love's language" from him. The poet thus juxtaposes a symbol of perfect Christian virtue with expectations of courtly love and chivalry by placing them together in a single stanza, one which supposedly describes Gawain entirely. But, as depicted in the various scenes with Lady Bertilak, such a dual and simultaneous maintenance of chivalric knightly ideals and Christian perfection is ultimately unsustainable.

In Gawain's interaction with Lady Bertilak, he attempts to uphold both his Christian and his knightly reputation. He seeks to adhere to and honor, to the best of his abilities, the emblem emblazoned in gold on his red shield, the pentangle. This five-point star symbolizes not only his fivefold Christian perfection but also linearity, a teleological temporal construct; its five straight lines directly contrast with the lady's circular girdle. Here the poet shows the tensions between and incompatibility of the two modes of temporal movement. Gawain's gold five-point star is linear and angular to the uttermost and describes Christian ideals, while Lady Bertilak's girdle is circular, harkening back to pagan cyclicism, the worship of seasons and their controlling deities. The curvature of the circle is linked to the feminine—to pregnancy, fertility, and Mother Nature. The girdle's greenness similarly connotes nature and the pagan. Even the Green Knight himself is a product and symbol of ancient female power, since he is made such by Morgan le Fay, the older sister of Arthur whose whim directs the plot and who poses as an "old withered lady," elderly and ancient (2445-64, 2463). Her title, "Morgan the Goddess," recalls ancient pagan cultural power and female deification (2452). Gawain's final failure to uphold the tenets of his pentangle and his acceptance of the circular girdle, invested with pagan mystical power and the lure of immortality, force one to note the fallibility of absolute ideologies. His failure also causes the poet's contemporaries to interrogate their own conceptions of Christian perfection, virtue, and honor, to examine anew the inherently oxymoronic quality of the "perfect Christian knight."

Other aspects of *Gawain* that show tensions between cyclic and linear construction are the matters of exchange, not the least of which is *Gawain*'s main plot point. The beheading game proposed by the Green Knight carries at its core the requirement of exchange, giving something with the promise of receiving back precisely that which was given. Indeed, after being beheaded, the Green Knight's severed head addresses Gawain, "To the Green Chapel come, I charge you, to take / Such a blow as you bestowed—you deserve, beyond doubt, / A knock on your neck next New Year's morn" (451-3). Here, the word rendered "come" derives from "chose" in the original Middle English text. The Middle English word *chose* can simply mean "to proceed quickly" or "to go." But the full definition of the word implies the matter of choice, "to choose or take one's way." Gawain chooses this way, so he must proceed with haste to the path and site of his choice. Gawain chooses to make the Green Knight's beheading blow into his final destination. Not only must Gawain proceed to his own decapitating, but he must also travel in the knowledge that he himself chooses this path. Gawain's fate, his impending beheading, is his own personal choice.

The severed head of the Knight then charges Gawain "to take / Such a blow as [Gawain] bestowed" (451-2). In these lines, he interjects "—you deserve, beyond doubt," emphatically stating that Gawain deserves the blow. The diction may cause the reader to question the Knight's logic, the truth of his words. Does Gawain truly deserve this stroke? Admittedly, he does deliver a blow so swift and powerful that the Knight is instantly and cleanly decapitated; the bleeding green head falls to the floor and rolls past many spectators' feet. Gawain does not hold back in beheading the Knight; he strikes the neck so fiercely that "the blade of bright steel [bites] into the ground" (426). But it was the Knight who barged in on Arthur's holiday festivities, demanding satisfaction and taunting Arthur's court. Gawain took up the game to spare his king, who was incensed at this insult to his nobility and was about to accept the challenge himself, a decidedly reckless decision which Gawain circumvents, preserving the land from the inevitable bloody struggle for power that would result from the death of a king without a definite heir apparent.

Is it then truly necessary for the Green Knight to interject to Gawain that he deserves "beyond doubt" such a blow (452)? Does Gawain actually deserve it? To answer this question, one must consider the intent of the original blow, the stroke which earns Gawain this "knock on [his] neck next New Year's morn" (453). Recall that after Arthur consents to give his young kinsman the game, he says to him, "'Keep, cousin,' said the king, 'what you cut with this day, / And if you rule it aright, then readily, I know, / You shall stand the stroke it will strike after'" (372-4). Gawain accepts the game without truly believing in the fact of the exchange. Indeed, it is likely that no man in that court, least of all Arthur, believes in the continuation of the game. Arthur avows that if Gawain guides the ax "aright," with swift and sure aim, to behead the Green Knight cleanly and does so successfully, Gawain will survive the blow dealt afterward, precisely because there will be no blow. Arthur stakes his faith and his nephew's life on the assumed failure of the game, the presumed breakdown of exchange due to the certain death of its executor. Gawain's acceptance of the game and deliverance of the blow, as well as Arthur's encouragement and exhortation of his courteous knight and kinsman, all hinge on their fundamental disbelief in even the remotest possibility of the carrying out of the exchange.

Herein lies the reason why Gawain delivers a blow to the Green Knight so powerful that the edge of the ax cuts into the ground beneath the Knight. Gawain wants to make absolutely sure that it will be impossible for him to receive a reciprocal decapitating blow to complete the terms of the exchange. This sheds light on the particular statement and interjection of the Knight, which before seemed so accusatory and unjustifiable: "I charge you, to take / Such a blow as you bestowed—you deserve, beyond doubt, / A knock on your neck next New Year's morn" (451-3). Gawain's blow is so excessive because he wants to ensure a failure of the exchange. As such, he does indeed deserve the forthcoming blow. Gawain chooses such a fate by dealing such a harsh stroke, which stems from disbelief in the fundamentally reciprocal nature of the beheading game.

The fundamental disbelief of both Arthur and Gawain in the completion of the beheading game is enormously revealing. As has been discussed, the poet strives to grapple with and bring to light the inherent conflicts between linear and cyclic constructs, between Christian teleological and pagan circular movements and viewpoints. Arthur and Gawain hold a simple, unmistakable, and apparently reasonable belief: A person cannot survive being decapitated. It is by no means a stretch to assume that the vast majority of mankind share resolutely in their belief. Those who lack it are most likely to be associated with the supernatural or magical. Authors throughout the centuries have played upon the idea of surviving a beheading, of living and moving literally without one's head. But such tales refer to supernatural or mystical forces, those beyond one's tangible understanding. Arthur's and Gawain's disbelief represents their absolute faith in a Christian viewpoint and teleological construction, a perspective which fails to account for men surviving beheadings, collecting their heads, and talking. But such absolutist attitudes are precisely what lead to the dilemma in which Gawain finds himself and what make Gawain's achievement of perfect and ideal Christian chivalric knighthood an oxymoronic impossibility.

Gawain and Arthur have such faith in their own teleological constructions of time and Christian viewpoint that they do not even consider the possibility that the Green Knight might survive the blow dealt to him, might survive it handily enough to deal a reciprocal blow of his own to Gawain. But upon surveying *Gawain*'s premise, their disbelief in the Knight's survival and absolute faith in their own decidedly non-supernatural viewpoints are tacitly ridiculous. The fact that Arthur and Gawain bear utter disbelief in the mere possibility of a reciprocal exchange, a fulfillment of the beheading game, is nonsensical when one considers that they are already in the presence of a seeming natural impossibility, an entirely green man whose origins could only be supernatural and pagan. In this way, the poet questions the wisdom of absolutist ideologies, be they Christian and teleological or pagan and cyclical. Nevertheless, the end of the poem still recalls and emphasizes the overwhelming prevalence of Christian doctrine and rectilinear time:

In the old days of Arthur this happening befell;
The books of Brutus' deeds bear witness thereto
Since Brutus, the bold knight, embarked for this land
After the siege ceased at Troy and the city fared
amiss.
Many such, ere we were born,
Have befallen here, ere this.
May He that was crowned with thorn
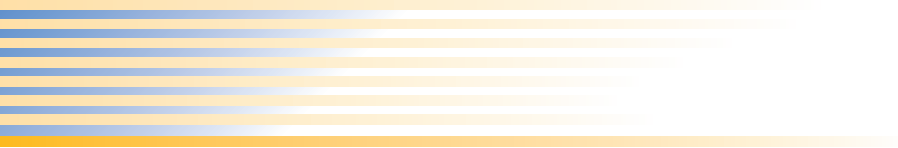Bring all men to His bliss! Amen. (2522-30)

Echoing the start of the poem is that imagined beginning, which allows for and is the progenitor of the poem's teleological temporal movement. The fact that the poet ends with such a teleological acknowledgement and confirmation of his own Christian faith, however, does not lessen or mitigate the impact of the conflicts and questions he seeks to bring to light through *Sir Gawain and the Green Knight*. It is rather an exhortation to believe wholeheartedly in whatever one might wish to believe, but to remain utterly open to other considerations and dilemmas. Indeed, the *Gawain*-poet's very composition of such a questioning, conflicted text sets him forth as an exemplar of how one might hold resolute beliefs whilst being utterly and rationally accepting of others' viewpoints, the consideration of alternative temporal movements and constructions of time and perspective.

WORKS CITED

Kermode, Frank. *The Sense of an Ending*. Oxford: Oxford University Press, 2000. Print.

Middle English Dictionary. Ann Arbor: U Michigan, 2001. Quod.lib.umich.edu/m/med. Web.

Sir Gawain and the Green Knight. Ed. J. R. R. Tolkien and E. V. Gordon. 1st ed. Ed. Norman Davis. 2nd ed. Oxford: Oxford University Press, 1967. Print.

Sir Gawain and the Green Knight. Trans. Marie Borroff. Ed. Marie Borroff and Laura L. Howes. New York: W. W. Norton & Company, 2010. Print.

ENDNOTES

[1] All citations from *Sir Gawain and the Green Knight*, excepting those in Middle English, are taken from the text translated by Marie Borroff and edited by Marie Borroff and Laura L. Howes. Citations in Middle English are taken from the text edited by J. R. R. Tolkien and E. V. Gordon, 2nd edition edited by Norman Davis. Full definitions of Middle English words are taken from the *Middle English Dictionary*.

Body Perceptions and Naturalness

Mira Ghabour, Ye Li

School of Business Administration

ABSTRACT

Beauty ideals shaped by the media are often extreme and perhaps even augmented; yet, people also have an inherent preference for naturalness. These two ideals can conflict when it comes to physical beauty, which raises the question of which is more important. This paper examines how people view naturalness for workout supplements and male body muscularity. A total of 102 online participants rated seven computer-generated images of men varying in muscularity from their own perspective, and the perspectives of a typical male and female American. They also rated six workout supplements such as steroids and protein bars for naturalness and likelihood of usage. We found that both men and women believe that other men and women prefer more muscular male bodies than in reality. This bias was particularly pronounced for men, particularly because women in fact prefer more moderately muscular men. We also found a strong relationship between how natural people thought workout supplements were and how likely they were to use them, although this relationship did not hold for steroids, suggesting that people who use steroids use them for other reasons. Importantly, we found a relationship between the preference for muscles and how likely people were to use unnatural workout supplements, even after controlling for demographics and exercise frequency. Although exploratory, this research suggests a potentially dangerous impact of extreme body images in the media and calls for further research on better understanding and perhaps breaking the link between biased body image perceptions and unsafe supplement usage.

Keywords: Naturalness, Perception, Body image, Masculinity, Gender Differences

AUTHOR

Mira Ghabour

School of Business Administration

Mira Ghabour is a fourth-year UCR student majoring in Business with a concentration in Finance. Being fascinated with body perceptions regarding both genders, and with how society views naturalness, Mira decided to start researching with Professor Ye Li in early 2014. After graduating in 2015, Mira hopes to continue in the business sector by starting her own company and possibly getting her MBA. Mira would like to thank Professor Li for his mentorship and guidance.

FACULTY MENTOR

Ye Li

School of Business Administration

Ye Li is an Assistant Professor of Management & Marketing. His research examines the affective, cognitive, and situational determinants of economic behaviors. His work has been published in *Proceedings of the National Academy of Sciences, Psychological Science, Psychology & Aging, Journal of Behavioral Decision Making, and Annual Review of Psychology*, and has been featured in the Chicago Tribune, CNN, Forbes, LifeHacker, Men's Health, New York Times, Salon, Scientific American, TIME, U.S. News & World Report, USA Today, and the Wall Street Journal.

INTRODUCTION

With every new generation, people's beauty preferences for a specific "look" or physique update, oftentimes with the guidance of the fashion and media industries (Syspeck, Gray, & Ahrens, 2004). Some external beauty ideals are fairly constant: For women, a thin figure with large breasts and a round bottom, and, for men, broad shoulders and a muscular body. Yet, media (e.g., television, movies, and magazines) often present images that are the result of augmentation, either via digital image manipulation (i.e., Photoshop) or body augmentation via implants or performance enhancing drugs (Reaves et al, 2004). Exposure to these images can create unattainable ideals, appearance anxiety, and damage to personal self-image (Grogan, 2007; Monro & Fuon, 2005). For men, these pressures in turn may lead to increased exercise supplement usage, including that of illegal, potentially dangerous supplements such as growth hormone and anabolic steroids (Fields et al, 2005).

Although media reinforces these unrealistic ideals, people may ironically be hardwired for the opposite, due to their inherent preference for naturalness over anything man-made (Rozin et al, 2004; Siegrist, 2008). Therefore, it is possible that while media pushes a certain standard of beauty, individual preferences may deviate. For example, according to Pope et al. (2000), "In both the United States and Europe, there appears to be a striking discrepancy between the body that men think women like and the body that women actually like."

This apparent discrepancy between people's preferences for naturalness and media images of "augmented" beauty raises four important questions: 1) Are men and women more attracted to natural or "augmented" beauty? 2) Are men and women calibrated about what other men and women find attractive? 3) Are people more or less willing to use natural versus unnatural supplements to achieve their fitness goals? 4) Do miscalibrated beliefs about what others view as attractive drive these preferences about workout supplements? We provide an initial exploration of these questions in this paper, while leaving the definitions of natural and unnatural open to people's own interpretation.

METHOD

We collected data using a custom-built Qualtrics survey. A total of 102 Amazon Mechanical Turk participants required to be at least 18 years of age and live in the United States (46 female, 56 male) were rewarded with a small monetary payment in exchange for completing the 8-minute survey.[1] All participants first read and digitally signed a consent form before starting the survey about "preferences and perceptions."

Participants next viewed a set of 7 images of computer-generated male bodies ranging in muscularity from slim to extremely muscular (see Figure 1), taken from the UCLA Body Matrices II (Frederick & Peplau, 2007). Importantly, we chose these images to only vary in muscularity, not fat content, and their faces were covered, so participants would base their ratings solely on the body, rather than facial features. Using a 7-point scale from 1 (Very unattractive) to 7 (Very attractive), participants rated the images three times: 1) "from your own perspective," 2) from "the perspective of a typical heterosexual, male American," and 3) from "the perspective of a typical heterosexual, female American." The order of these three blocks was counterbalanced. Block order did not affect results so we will not discuss it further.

Next, participants were asked to "define what is 'natural'" and "what is 'unnatural'," and then rated 6 products (weight loss supplements, oral steroids, steroid injections, protein powder, protein bars, and creatine) related to working out on a 5-point scale from "Completely Unnatural" to "Completely Natural," again allowing participants to use their own definition of natural. They then further rated their own likelihood of using these products "to improve your physique" on a 7-point scale from "Very unlikely to "Very likely." Participants could also report that they did not know what any of the items were, in which case we excluded the data point.
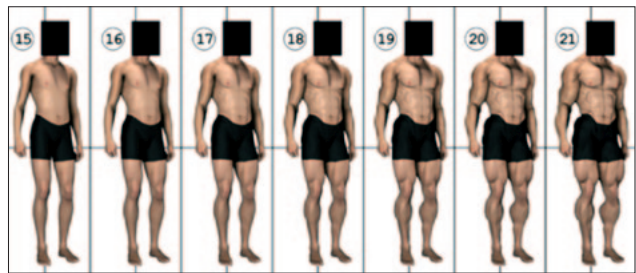
Figure 1. UCLA Body Matrices II (Frederick & Peplau, 2007)— Men in Shorts

Participants then rated their agreement with 12 statements regarding supplements, usage risks, and body image on a 7-point scale from "Strongly Disagree" to "Strongly Agree." Finally, they completed a demographics questionnaire including questions about their exercise frequency for strength, cardiovascular, and flexibility training.
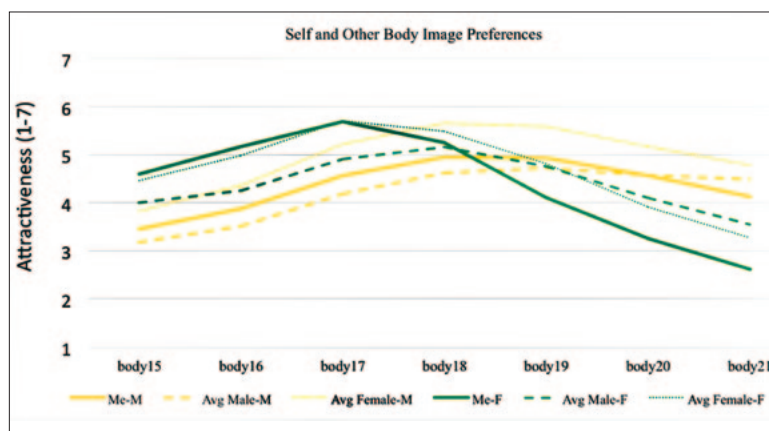
RESULTS

Preferences for Male Muscularity

Recall that all participants were asked to rate seven computer-generated male bodies ranging in muscularity three times: from their own perspective, and from the perspectives of typical American males and females. Figure 2 shows the average ratings of each of these bodies, with separate lines for each gender of the participant and perspective.

Female. For female participants, body 17 (slightly less than the midpoint of muscularity) was rated as most attractive (M = 5.43). In general, less muscular men were rated as more attractive than more muscular men (Ms = 5.16 vs. 3.33, Paired $t(45) = 5.65$, $p < .0001$), with even the least muscular man (M = 4.61) being rated higher than the three most muscular men ($t(45) = 3.90$, $p < .001$), and the most muscular man was rated as least attractive (M = 2.63). Female participants believed other women had similar preferences for skinny to moderately muscular men (Ms = 5.07 vs. 5.16, $t(45) = 0.81$, ns) but believed that other women find the more muscular men more

attractive than they did themselves: their ratings from the perspective of the typical female were on average 0.68 points higher than their own ratings for bodies 19 through 21 (Ms = 4.01 vs 3.33, $t(45) = 3.97$, $p < .001$). Female participants also thought that the typical man would find more muscular bodies to be more attractive than they did themselves (Ms =4.14 vs. 3.33, $t(45) = 2.90$, $p < .01$) but also thought they would find less muscular bodies less attractive than they did themselves (Ms =4.39 vs. 5.16, $t(45) = 3.27$, $p < .01$).

Male. We next turn to male participants, who rated bodies 18 and 19 as the most attractive (Ms = 4.96 and 4.95), and generally did not like the three less muscular bodies (Ms = 3.46, 3.89, and 4.58, compared to body 18: $t(56) = 5.23$, $p < .0001$). This pattern differed from female participants, with male participants preferring more muscular bodies than female participants (who most preferred body 17). When judging from the perspective of a typical male, male participants thought that other men would have a similar pattern of preferring more muscular bodies, but even more disapproving of less muscular bodies ($M_{self} = 3.98$ vs. $M_{other\_men} = 3.63$, $t(56) = 2.52$, $p < .05$) and marginally more approving of the most muscular body (body 21; $M_{self} = 4.14$ vs. $M_{other\_men} = 4.49$, $t(56) = 2.52$, $p < .05$). Even more interestingly, men's beliefs about the typical female's preferences showed a nearly identical pattern as their own ratings (body index $M_{self} = 1.74$ vs. $M_{women} = 2.14$, $t(56) = 0.58$, ns) but shifted up by an average of 0.58 (Ms = 4.37 vs. 4.95, $t(56) = 3.96$, $p < .001$), suggesting that men projected their own preference for muscularity onto women and then further exaggerated them.

Body Image Index. To formally compare male and female preferences, we calculated a *body image index* (BII) for each participant, subtracting their total rating for the three least muscular bodies from the total rating for the three most muscular bodies (i.e., bodies 19, 20, and 21 minus bodies 15, 16, and 17). We also calculated BII_m and BII_f for what participants believed about other male and other female Americans' preferences for muscular bodies. Index scores roughly measure the strength of preference for more muscular male bodies, with numbers greater than zero suggesting a preference for more muscular bodies.

Figure 2. Attractiveness ratings of computer-generated male bodies ranging from least muscular (body 15) to most muscular (body 21), from own perspective, perspective of typical American male, and perspective of typical American female. Data are split by gender of participant.

Unsurprisingly, BII was higher for male than female participants (M = 1.73 vs. -5.48, $t(101)$ = 6.37, p < .0001). Interestingly, female participants' beliefs about the typical male American's preferences were on average fairly similar to male participants' actual ratings for both less muscular bodies (M_f = 4.39 vs. M_m = 3.97, $t(101)$ = 1.46, ns) and more muscular bodies (M_f = 4.14 vs. M_m = 4.56, $t(101)$ = 1.25, ns). Although woman projected their own preferences onto other women (correlation between BII and BII_f = .72, p < .0001), they seemed to be able to take a different perspective for thinking about a man's preferences (correlation between BII and BII_m = .29, p = .053)

On the other hand, correlations showed that men projected their preferences onto both genders: BII was highly correlated with BII_m (r = .69, p < .0001) but also highly correlated with BII_f (r = .52, p < .0001). This distortion of beliefs could be particularly damaging if these men are exercising to conform to what women find attractive, a possibility that we explore below.

In summary, both men and women think other men and women find a more muscular physique more attractive than in reality, despite preferring middle-of-the-range bodies themselves. People seem to have a preconception that people prefer a certain body type for a man and yet their own preferences are different. Cross-gender beliefs were particularly informative: Whereas women had generally accurate beliefs about men's muscularity preferences, men's beliefs were strongly egocentric, incorrectly thinking that women prefer a more muscular man. In fact, actual ratings for male and female participants were quite divergent: Women preferred the less muscular bodies, whereas men preferred the more muscular bodies. We next explore whether distortions in beliefs can explain the increasing reliance on workout supplements.
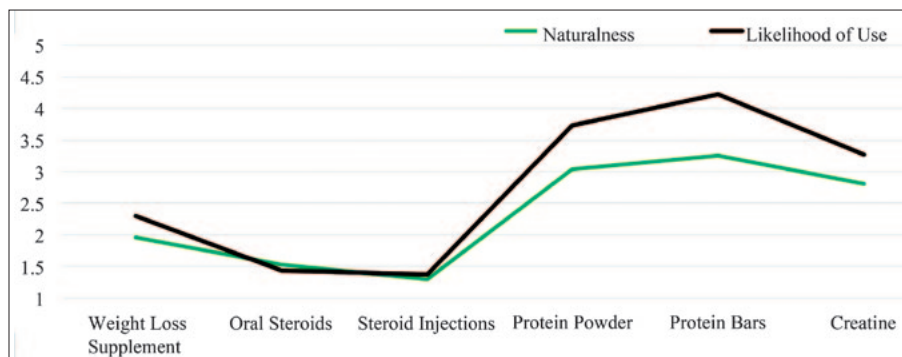
Workout Supplement Naturalness and Likelihood of Use

Previous research has found that many men and some women turn to workout supplements to improve the results of their physical regiment (Fields et al, 2005). We next investigate one potential antecedent of supplement usage: how natural the supplement seems. Figure 3 shows how natural participants rated each of the six workout supplements and how likely they were to use such products for their workouts. Importantly, both oral steroids and steroid injections had extremely low ratings for both naturalness and likelihood of taking them, perhaps because they are actually illegal and therefore taboo. On the other hand, protein bars had the highest naturalness and likelihood of usage.

The similarity between the two lines shows a clear relationship between how natural a product is and how likely people are to use it, consistent with prior research on natural products. Collapsing data across all six supplements, we found a strong positive correlation between naturalness and likelihood of usage (r = .53, p < .0001), which suggests that naturalness is taken into consideration when deciding whether or not to take a supplement.

Table 1. Regression results for likelihood of usage as a function of perceived product naturalness.

Product	Linear Regression	Student's t-stat	p level
Weight-Loss Supplements	y = 1.28 + 0.51x	3.09	p = .003
Oral Steroids	y = 1.21 + 0.15x	1.24	p = .219
Steroid Injections	y = 1.20 + 0.09x	0.65	p = .515
Protein Powder	y = 1.23 + 0.83x	4.95	p < .001
Protein Bars	y = 2.27 + 0.60x	3.77	p < .001
Creatine	y = 1.59 + 0.60x	3.64	p < .001

Figure 3. Average naturalness rating and likelihood of use for various workout supplements. Naturalness rated on 1 to 5 scale and likelihood of usage rated on 1 to 7 scale.

Table 1 shows individual tests of this relationship for each product. Surprisingly, although the relationship between perceived naturalness and likelihood of usage was strong and significant for four of the products, it did not hold for oral steroids or steroid injections. These results were mostly unchanged when we controlled for gender, age, education, race, and frequency of exercise (results not shown). This lack of relationship between perceived naturalness and likelihood of use for steroids suggests that even though people view them as unnatural, some people may nonetheless be willing to take them for other reasons, perhaps their higher perceived efficacy. That is, perhaps some people would rather have quicker muscle gain results than to take a more natural but slower route. However, we urge caution in interpreting these results: even though participants were familiar with the various supplements, only four participants actually indicated a positive likelihood of using either type of steroid. More research is needed to replicate this result with a larger sample.

Body Image and Supplement Perceptions. To determine whether body image perceptions from the first part of the survey are related to naturalness perceptions and likelihood to use workout supplements, we again used the body image index (BII, with higher scores corresponding to greater preference for muscularity). Correlating BII with naturalness ratings and likelihood ratings, we found that participants who personally preferred more muscular bodies were more likely to use all supplements (rs = .17 to .43, all ps < .05, except for steroid injections p = .08) but not more likely to see the supplements as more natural. Even after controlling for demographics, perceived naturalness, and exercise frequency, participants with higher BII were more likely to use oral steroids, steroid injections, and weight-loss supplements, suggesting that these participants were particularly eager to reach their ideal physiques, even if it meant using potentially dangerous and often illegal supplements.

To check whether miscalibrated perceptions about other people's preferences for muscularity influenced usage of supplements, we correlated BII_m and BII_f with usage likelihood for male and female participants separately. For the 53 men, neither BII_m nor BII_f was related to likelihood of using any supplement (all r < .19, ns), suggesting that only their own desire for muscularity drove supplement usage. For the 35 female participants, BII_m was unsurprisingly unrelated to supplement use (all r < .14, ns), but BII_f was related to likelihood to use weight loss supplements (r = .35, p < .05), protein bars (r = .34, p < .05), and creatine (r = .34, p < .05), and marginally related to protein powder use (r = .29, p < .10). However, these effects are mostly due to the high correlation between BII and BII_f for female participants, and therefore simply reflect these women's own preference for muscularity. When BII is controlled for, all BII_f correlations disappeared. Again, caution is required due to small sample sizes when splitting by gender.

*Table 2. Agreement (1 - 7) with statements about supplement usage, risks, and body image, by gender. * p < .05, ** p < .01 ** p < .001.*

Statement	Male	Female	Overall Std. Dev.	t-stat for gender effect
1. I have a fair amount of knowledge about dietary and exercise supplements.	4.47	4.24	1.96	0.60
2. Unnatural supplements are more effective than natural supplements in regards to muscle building.	4.95	3.85	1.80	3.21**
3. Natural supplements pose short-term health risks.	2.32	2.37	1.38	0.20
4. Unnatural supplements pose short-term health risks.	5.11	5.24	1.39	0.48
5. Natural supplements pose long-term health risks.	2.28	2.35	1.34	0.25
6. Unnatural supplements pose long-term health risks.	5.98	6.04	1.13	0.27
7. Women generally find more muscular men attractive.	5.58	4.74	1.39	3.19**
8. Muscular men who use natural supplements are impressive.	5.56	5.13	1.50	1.46
9. Muscular men who use unnatural supplements are impressive.	3.40	2.17	1.80	3.65***
10. I think using supplements can help me reach my ideal/goal weight.	4.77	3.63	1.87	3.22**
11. Taking natural supplements can lead to a natural body image.	5.26	4.89	1.62	1.16
12. Taking unnatural supplements can lead to a natural body image.	3.40	2.50	1.78	2.64**

Supplement Use, Naturalness, and Health Risks

First, there was a strong preference for natural over unnatural supplements. Participants rated natural supplements as having less short-term and long-term health risks, as being more impressive as part of a muscular man's impressiveness, and being more likely to lead to a natural body image. Second, there were gender differences for a few of the questions: Men were more likely to believe that unnatural supplements are more effective than natural supplements with regards to muscle buildings and that taking them can still lead to a natural body image. Men were also less disapproving than women were of muscular men who used unnatural supplements. Consistent with the body image rating results, men were again more likely to agree that women generally find more muscular men attractive.

Finally, we briefly examined participants' open-ended responses to questions about how they defined what is natural and what is unnatural. Due to space constraints, we merely describe the results rather than formally analyze them. By far the most common answer was that something "unnatural" revolved around the idea of being man-made, artificial, or altered by humans in any way. Interestingly, a few participants went further in discussing how sometimes it may be difficult to apply these definitions due to ambiguities about the initial raw product, the extracting process, and the manufacturing process. For instance, vitamin C is natural, but the extracting process or addition of preservatives may be considered unnatural. Although these free response varied somewhat from person to person, any formally coded differences between people's definitions did not relate to differential responses on any other portion of the survey.

DISCUSSION

Due to constant exposure to media images from television, movies, and magazines, we have become acculturated to a way of thinking about beauty that is narrow, extreme, and oftentimes "augmented." Yet, we find that human desire for naturalness seems to trump media's influence, at least in some cases. Beauty and naturalness may seem unrelated; yet, we have shown how they are entwined and even come into conflict. Although people think others view extremely muscular men as attractive, both men and women's actual preferences are far more moderate.

Our survey found that both men and women believe that other men and women prefer more muscular male bodies than in reality. This bias was particularly pronounced for men, particularly importantly because women in fact prefer more moderately muscular men. We also found a strong relationship between how natural people thought workout supplements were and how likely they were to use them, although this relationship did not hold for steroids, suggesting that people who use steroids use them for other reasons. Importantly, we found a relationship between the preference for more muscular bodies and how likely people were to use unnatural workout supplements, even after controlling for demographics and exercise frequency, suggesting one route that leads to steroid use. Yet, we surprisingly found no relationship between people's beliefs about other people's preferences for muscularity and likelihood of using workout supplements, meaning that it is one's personal preference for muscularity that drives supplement use, not miscalibrated beliefs about others.

Although these results are best seen as exploratory due to the relatively small sample size (especially when split by gender), our findings suggests a potentially dangerous impact of extreme body images in the media and calls for further research on better understanding and perhaps breaking the link between biased body image perceptions and unsafe supplement usage. Future studies need to better understand the causal relationship (rather than just correlational) between naturalness and supplement usage, and to better understand the motivational processes that underlay body image perceptions so that we can more effectively call for change. Perhaps one solution is that the media needs to take action and incorporate a broader range of different types of beauty, from different ethnicities, heights, and weights.

On the other hand, when it comes to what is considered natural and unnatural, the official definition needs to be narrowed to provide a clearer distinction between the two. Organic and natural products are increasingly popular (Dimitri & Green, 2000); yet, the public can be told a product is natural through marketing communications, when in reality that product may not be
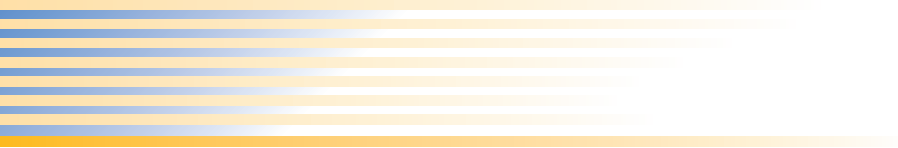
all that natural or even healthy. This suggests that there is much public service that media can do to address relatively consumers' uncertainty about the definitions and benefits to naturalness in a way that promotes safer and more sustainable body images.

REFERENCES

Dimitri, C., & Greene, C. (2000). Recent growth patterns in the US organic foods market. *ERS Agriculture Information Bulletin*.

Field, A. E., Austin, S. B., Camargo, C. A., Taylor, C. B., Striegel-Moore, R. H., Loud, K. J., & Colditz, G. A. (2005). Exposure to the mass media, body shape concerns, and use of supplements to improve weight and shape among male and female adolescents. *Pediatrics*, 116(2), 214-220.

Frederick, D. A., & Peplau, L. A. (2007). The UCLA Body Matrices II: Computer-generated images of men and women varying in body fat and muscularity/breast size to assess body satisfaction and preferences. In *8TH Annual Meeting of the Society for Personality and Social Psychology*. Retrieved from http://dfred.bol.ucla.edu/UCLAbody.html on March 30, 2015.

Grogan, S. (2007). *Body image: Understanding body dissatisfaction in men, women and children*. London: Routledge.

Monro, F., & Huon, G. (2005). Media-portrayed idealized images, body shame, and appearance anxiety. *International Journal of Eating Disorders*, *38*(1), 85-90.

Reaves, S., Bush Hitchon, J., Park, S. Y., & Woong Yun, G. (2004). If looks could kill: Digital manipulation of fashion models. *Journal of Mass Media Ethics*, 19(1), 56-71.

Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: instrumental and ideational/moral motivations, and the contrast between foods and medicines. *Appetite*, 43(2), 147-154.

Pope Jr, H. G., Gruber, A. J., Mangweth, B., Bureau, B., Jouvent, R., & Hudson, J. I. (2000). Body image perception among men in three countries. *Body Image*,157(8).

Siegrist, M. (2008). Factors influencing public acceptance of innovative food technologies and products. *Trends in Food Science & Technology*, 19(11), 603-608.

Sypeck, M. F., Gray, J. J., & Ahrens, A. H. (2004). No longer just a pretty face: Fashion magazines' depictions of ideal female beauty from 1959 to 1999. *International Journal of Eating Disorders*, 36(3), 342-347.

FOOTNOTES

[1]We attempted an initial pilot test by asking people entering or leaving supermarkets ($n = 25$) but efforts were halted due to a high degree of rejection and concerns about selection bias. Although we do not report them here, in-person surveys yielded about the same results as the online data.

Variable Response of Native Species to Nitrogen and Soil Inoculum from Native and Invasive Species

Amanda Haraksin[1], Justin M. Valliere[2], and, Edith B. Allen[2,3]

[1]Department of Biology
[2]Department of Botany and Plant Sciences
[3]UCR Center for Conservation Biology

ABSTRACT

Nitrogen deposition from anthropogenic sources is increasing and can lead to excess nitrogen entering the environment, causing changes in plant community composition and the loss of plant diversity. Nitrogen deposition has been shown to decrease the success of slow growing native plants, increase the invasion of annual grasses in coastal sage scrub (CSS) habitat, and influence the soil biotic communities. We performed a greenhouse experiment to explore the effects of nitrogen, the soil community, and the interaction between nitrogen and the soil community on the growth of five native CSS plant species, *Acmispon glaber, Encelia californica, Eriogonum cinereum, Salvia leucophylla,* and *Stipa pulchra*. This study has implications for the restoration of the CSS community in areas facing nitrogen deposition and invasion of nonnative grasses. We hypothesized that added nitrogen will lead to higher native plant biomass, species will respond differently to sterile, invasive, and native soil inoculum, and the soil community can affect the plant growth responses to nitrogen for some species. Generally we found that added nitrogen led to higher plant biomass, and there were no significant differences in plant growth between the live soil treatments under either high nitrogen or low nitrogen. For *Eriogonum, Acmispon*, and *Stipa*, we found the soil community affected the plant's growth response to nitrogen. Since we found no significant differences in plant growth between the native and invasive soil treatments, we can conclude that aboveground competition likely plays a larger role than the soil community in the dominance of invasive species.

Keywords: nitrogen deposition, coastal sage scrub, soil community, native species, invasion

AUTHOR

Amanda Haraksin

Department of Biology

Amanda Haraksin is a fourth year student majoring in Biology. She has been a research assistant in Dr. Edith Allen's lab since the summer of 2013. She is a member of the National Society of Collegiate Scholars and Phi Beta Kappa Honors Society. She plans to go to graduate school within the next few years and aims for a career in natural resources management, conservation, and/or restoration. Amanda thanks her mentors Justin Valliere and Edith Allen for their continued support throughout her research.

FACULTY MENTOR

Edith Allen

Department of Botany and Plant Sciences
UCR Center for Conservation Biology

Professor Allen's major focus is restoration ecology, and she has worked on the restoration of grasslands, shrublands, deserts, boreal forest, and tropical forest, including disturbances such as mining, landfills, roadsides, grazing, fire, and invasive species.

INTRODUCTION

Nitrogen (N) deposition is increasing due to human activities, and may lead to an excess amount of N in soils. Excess N in the environment has negative effects on biotic communities, including changes in plant community composition and the loss of plant diversity (Bobbink et. al 2010). Nitrogen deposition in western U.S. ecosystems is typically found in regions with a mix of emissions sources that include urban, mobile, agricultural, and industrial sources (Fenn et. al 2003). In Southern California, a higher level of atmospheric N is correlated with higher amounts of N in the soil available to the plants, which has implications for California's coastal sage scrub (CSS) community (Padgett et al. 1999). The addition of N to the soil has been shown to increase the growth of nonnative grasses and decrease the growth of native shrubs, leading to the conversion of the coastal sage shrublands to exotic grasslands (Padgett and Allen 1999, Kimball et al. 2014).

Invasive species are species that have been introduced into a new environment, typically due to the indirect or direct activities of humans, where they lack natural competitors and can cause economic harm, reduce plant biodiversity, and displace native species (Sakai et. al 2001, Pimentel et. al 2005). Nitrogen deposition has the ability to increase the dominance of invasive plant species in CSS communities, where the slow growing native plants are adapted to low nutrient soils and the excess N in the soil creates an environment favorable to faster growing plants (Dukes and Mooney 1999). Studies of N fertilization and N deposition have shown that as N increases, the growth of invasive grasses increases since they are better able to compete for resources than native shrubs, leading to a decline in native shrubs and the depletion of native seed banks (Cione et. al 2002, Fenn et. al 2003). The increase of invasive grasses increases the fire frequency and they are able to establish more quickly than the native shrubs after the fire, especially under periods of drought and high N deposition, which may lead to the permanent conversion of the CSS communities into exotic grasslands (Kimball et. al 2014).

Nitrogen deposition can not only affect plant communities, but soil communities as well. Soil communities, which are comprised of bacteria, archea, protists, nematodes and other

microfauna, and fungi, can affect plant growth positively or negatively. Pathogens decrease the success of the host plant, whereas mutualists are beneficial to both the host plant and microbes, where the microbes typically increase the nutrients available to the plant. Mutualistic microbes can be host specific but some such as mycorrhizae can infect a wide range of hosts, which allows the invasive species to form a mutualism with these fungi and live in an environment where it lacks plant-specific pathogens (Callaway et. al 2004). Invasive plants tend to influence the soil community by generating plant soil feedbacks that benefit themselves, whereas the native plants tend to suffer from negative feedbacks due to the accumulation of pathogens (Perkins and Nowak 2013). Therefore, invasive plant species may be able to exhibit strong competition against the native plants in CSS communities due to their efficiency in using N and their relationship with the soil community. It is important to consider soil communities when looking at plant responses to N because the soil biota can affect the uptake of nutrients such as N, and the addition of N can also affect the plant's relationship with the soil community. For example, N fertilization (which simulates the effects of N deposition) selects for vesicular arbuscular mycorrhizal fungi that are inferior mutualists and tend to provide their host with fewer nutrients from the soil by producing fewer hyphae and arbuscules than fungi in unfertilized soil (Johnson 1993). Due to the effects of N and the soil community on plant growth, we performed a greenhouse study to explore their effects on five native CSS species, which has implications for the restoration of the CSS community in areas that have faced increased N deposition and invasion of exotic grasses.

The objectives of this experiment were to test:
1. The effects of N availability on the growth of five native CSS plant species.
2. The effects of native and invasive soil microbial communities on the growth of these native CSS species.
3. The interaction of soil microbial communities and N on the growth of these native CSS species.

We hypothesized that the species will respond differently to soil inoculum (a small sample of the soil microbial community) and N treatments. We hypothesized that added

N will lead to higher plant biomass, species will respond differently to sterile, invasive, and native soil inoculum, and the soil community can affect the plant responses to N for some species. We hypothesized that the native species may have higher biomass in soil inoculum from invasive plants under low N conditions where they have reduced pathogens and can benefit from the mutualistic fungi, and under high-N conditions and sterile soils, where the native plants lack pathogens and inferior mutualists.

METHODS

We performed a greenhouse experiment to understand the effects of N and the soil community on the growth of native CSS plants. The potting soil used for this experiment was UC mix. We collected our inoculum in October 2014 from Rancho Sierra Vista, which is located in the Santa Monica Mountains National Recreation Area in eastern Ventura County (34.15° N, 118.96° W). Native soil inoculum was collected from the rhizosphere of mature CSS (*Acmispon glaber, Artemisia californica*, and *Eriogonum cinereum*) and invasive inoculum was collected from an adjacent exotic annual grassland dominated by *Bromus* and *Avena* species. The inoculum was collected from the top 10 cm of soil, sieved through 1 cm^2 mesh (hardware cloth), transported to UCR, and mixed thoroughly before separating (half for live inoculum, half for sterilized inoculum). The sterilized inoculum underwent a 24 hour steam treatment, 48 hour incubation, followed by another 24 hour steam treatment.

The pots used for this experiment were D40H Deepots Stuewe & Sons, Inc. Tangent, Oregon which are 6.4 cm in diameter and 25 cm deep. All pots used in this experiment were washed, sterilized in 10% bleach, and rinsed with deionized water prior to potting. The bottoms of the pots were stuffed with a 30 cm x 43 cm piece of crumpled newspaper to prevent soil loss.

The species used for this experiment, all native CSS species, were *Acmispon glaber, Encelia californica, Eriogonum cinereum, Salvia leucophylla,* and *Stipa pulchra*. The two treatments were N level (low N and high N) and inoculum (sterile, native, and invasive). We had 10 replicates of each treatment for a total of 300 pots.

Approximately 485 grams of sterile UC mix soil was added to each pot and inoculum was added approximately 5 centimeters below surface level and mixed in. To control for potential differences in nutrients in the two types of inoculum, to the live inoculum treatment, we added sterilized inoculum of the other treatment. For the sterile treatment we added 25 g of sterile native inoculum and 25 g of sterile invasive inoculum. For the native treatment we added 25 g of live native inoculum and 25 g of sterile invasive inoculum. For the invasive treatment we added 25 g of live invasive inoculum and 25 g of sterile native inoculum. In late October 2014, pots were seeded, covered with a few cm of UC mix, and watered with deionized water. For the first few weeks the plants were watered every 1-2 days and then every 3-5 days, as needed, after the plants were established. Pots were randomly arranged on greenhouse benches every 3-5 days to account for potential differences in the microclimate.

The low-N treatments only had the amount of N in the soil mix, which was 0.0302 mg/cm^3 of N from nitrate (NO_3^-). The high-N treatments were fertilized 3 times, November 11th, November 26th, and December 11th, 2014 in order to simulate high soil N availability due to N deposition. The total amount of added N was 0.0465 mg/cm^3 from ammonium nitrate, which contains the two dominant forms of reactive N. Therefore high-N treatments had a total of 0.0767 mg/cm^3 of N (including the amount of N in the soil and added N). The plants were harvested after 75 days of growth, dried in an oven, and weighed to obtain the aboveground biomass. We used dried aboveground biomass to demonstrate plant growth and indicate how productive the plants were under the N and inoculum treatments.

We ran an ANOVA to analyze the differences between inoculum, N, and the interaction between inoculum and N on the aboveground biomass for each species. We then used Tukey's t-test to determine significant differences among the treatments.

RESULTS

The native species we tested had differing growth responses to nitrogen and the soil community. Generally we found that the plants in the high-N treatments had a higher biomass than the plants in the low-N treatments. However these responses sometimes differed with the inoculum treatment.

Biomass of *Acmispon* was significantly affected by inoculum (P = 0.0481), N (P= 0.0042) and the interaction between inoculum and N (P = 0.0219). In sterile inoculum, the plants grown with low N had significantly less biomass than the high-N treatment, but when grown in either of the live inoculum treatments there was no significant difference between N treatments.

Biomass of *Encelia* was significantly affected by inoculum (P=0.0168) and N, (P<0.0001) and the only significant difference in biomass found for *Salvia* was for N (P<0.0001). For *Encelia* and *Salvia*, plants grown under high N had higher plant biomass and there were no significant differences between soil treatments.

We found statistically significant differences in the biomass of *Eriogonum* for N (P<0.0001) and for the interaction between inoculum and N (P=0.00316). Added N led to higher plant biomass, and under high N, the plants in the invasive inoculum had a lower biomass than plants grown in sterile conditions.

Biomass of *Stipa* was significantly affected by inoculum (P=0.0161), N (P=0.0042), and the interaction between inoculum and N (P=0.0219). The addition of N led to higher biomass in the invasive soil, but not in the other treatments. Plants had a higher biomass in live soils, but only under high N.
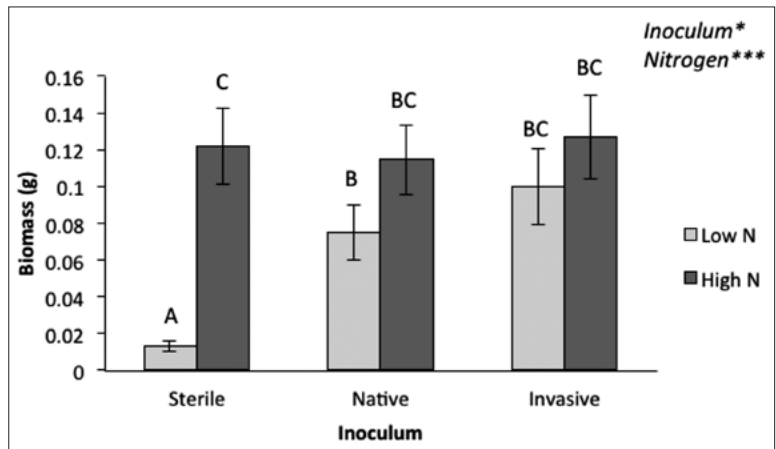
Fig. 1: *The biomass of Acmispon glaber in different nitrogen and inoculum treatments. Different letters indicate significantly different means based on pairwise Tukey's comparisons at α<0.05.*
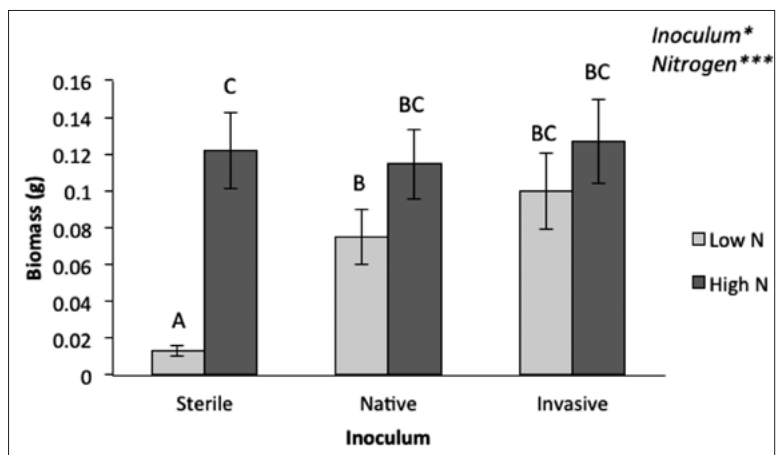
Fig. 2: *The biomass of Encelia californica in different nitrogen and inoculum treatments. Different letters indicate significantly different means based on pairwise Tukey's comparisons at α<0.05.*
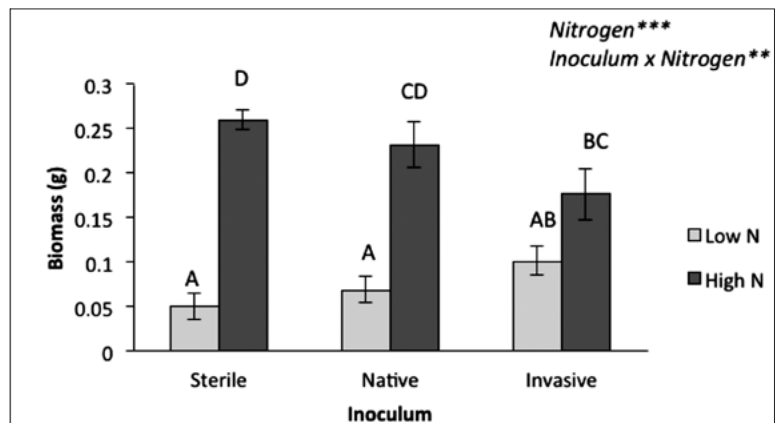
Fig. 3: *The biomass of Eriogonum cinereum in different nitrogen and inoculum treatments. Different letters indicate significantly different means based on pairwise Tukey's comparisons at α<0.05.*
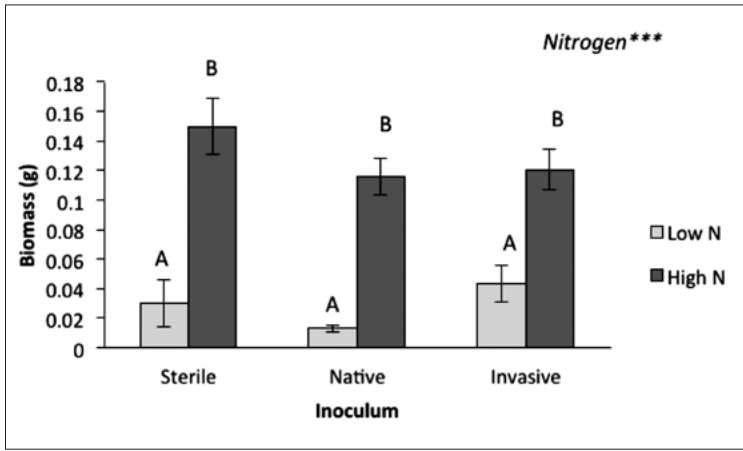
Fig. 4: The biomass of Salvia leucophylla in different nitrogen and inoculum treatments. Different letters indicate significantly different means based on pairwise Tukey's comparisons at α<0.05.
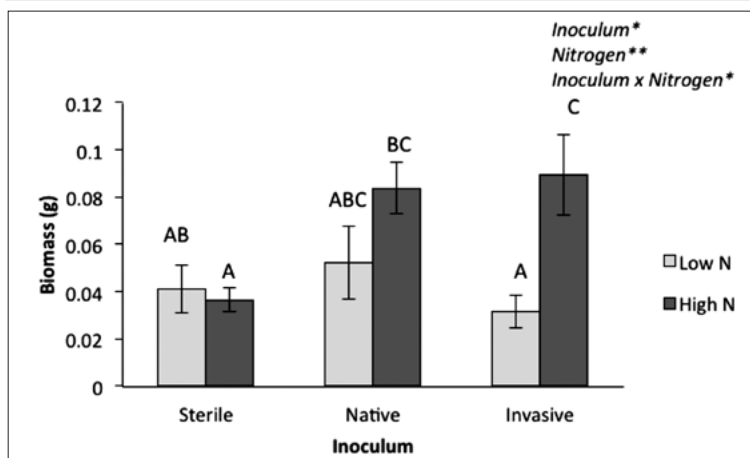

Fig. 5: The biomass of Stipa pulchra in different nitrogen and inoculum treatments. Different letters indicate significantly different means based on pairwise Tukey's comparisons at α<0.05.

DISCUSSION

We found that added N generally led to higher growth of our species with the effects of inoculum varying across the species, which has implications for their establishment.

Since added N led to higher growth responses for all inoculum treatments in *Encelia* and *Salvia,* and the plants in the sterile treatments did not significantly differ in biomass compared to the live inoculum treatments, the soil community does not appear to enhance or inhibit the growth of these species (Fig. 2, 4). Although both of these species had higher biomass with higher levels of N, in areas of high N deposition they will undergo high aboveground competition with the invasive

annual grasses (Kimball et al. 2014, Cox et al. 2014). In areas of low N deposition, they may establish successfully due to a reduced amount of competition with the invasive species and their lack of dependence on the soil microorganisms to grow effectively.

Acmispon is a legume, which means that it forms a relationship with N fixing bacteria to make more N available to the plant (Steppan 1991). This explains the low plant biomass under low N and sterile soil, (Fig. 1) because *Acmispon* needs to either form a mutualism with the soil bacteria or receive added N to grow effectively. *Acmispon* has the potential to establish successfully in areas with low N deposition, since it can form relationships with the soil bacteria to make more N available to the plant, as well as in areas with high N deposition where it can benefit from added N.

Eriogonum had higher biomass in sterile soil than invasive soil under high-N conditions (Fig. 3), meaning that in areas of high N deposition dominated by invasive species, *Eriogonum* may have trouble establishing due to the competition with invasive species and its relationship with the soil community (Perkins and Nowak 2013, Cione et. al 2002). These results suggest the invasive inoculum either includes pathogens which reduce the growth of *Eriogonum* (but not the other four species), or has mycorrhizal fungi that are not as beneficial to its growth as in native inoculum.

Stipa had higher biomass with added N and live inoculum (Fig. 5). In sterile soils, N did not have an effect on plant growth, which may indicate that the plant's relationship with the soil community enables the plant to uptake added N. Since there were no significant differences between growth in the sterile and live inoculum under low N, *Stipa* may be efficient at using low levels of N, but may need to form mutualisms with soil microbes to be able use higher levels of N (Callaway et. al 2004). *Stipa* will most likely establish successfully in areas with low N deposition or in areas of high N deposition which include the soil microbes which allow *Stipa* to use nitrogen more effectively.

Amanda Haraksin

CONCLUSIONS

It is important to understand how N and the soil community influence the growth of native plant species, because this will directly influence their ability to compete with invasive species. Our results provide valuable insight into how CSS species will perform in soils subject to N deposition and invasion. For some species (*Encelia* and *Salvia*) N level was the only factor leading to differences in plant growth, and for the others (*Acmispon*, *Eriogonum* and *Stipa*) both N and inoculum played a role in plant growth. In two of our species (*Acmispon* and *Stipa*) we found the soil community can affect the plant's ability to take up N. The growth responses suggest that *Acmispon* requires inoculum for N fixing bacteria under low N, *Stipa* requires mycorrhizal inoculum for uptake of high levels of N, and *Eriogonum* may be limited in growth by the microbial community in high N, invaded soil. Species generally had higher growth with added N, but in areas with high N deposition they may not be able to compete with the faster growing invasive grasses. Even though the native species had differing responses to the soil community, we found no significant differences in plant growth between the native and invasive soil treatments under high N, which indicates that aboveground competition may play a larger role in the dominance of invasive species than the soil community under high N deposition. Therefore, the native plants in this study have the potential to do well under high N deposition in soils dominated by invasive species, once the invasive species and their seed banks are removed. However, further analyses of root biomass and plant tissue N are important to gain a full understanding of the native plant growth, and root infection by microscopy is needed to confirm the role of different species of microorganisms in these native plant species.

REFERENCES

Bobbink, R., Hicks, K., Galloway, J., Spranger, T., Alkemade, R., Ashmore, M., . . . De Vries, W. (2010). Global assessment of nitrogen deposition effects on terrestrial plant diversity: a synthesis. *Ecological Applications, 20*(1), 30-59. doi: Doi 10.1890/08-1140.1

Callaway, R. M., Thelen, G. C., Rodriguez, A., & Holben, W. E. (2004). Soil biota and exotic plant invasion. *Nature, 427*(6976), 731-733. doi: Doi 10.1038/Nature02322

Cione, N. K., Padgett, P. E., & Allen, E. B. (2002). Restoration of a native shrubland impacted by exotic grasses, frequent fire, and nitrogen deposition in southern California. *Restoration Ecology, 10*(2), 376-384. doi: DOI 10.1046/j.1526-100X.2002.02038.

Cox, R. D., Preston, K. L., Johnson, R. F., Minnich, R. A., Allen, E. B. 2014. Influence of landscape-scale variables on vegetation conversion in southern California, USA. Global Ecology and Conservation 2: 190-203.

Dukes, J. S., & Mooney, H. A. (1999). Does global change increase the success of biological invaders? *Trends in Ecology & Evolution, 14*(4), 135-139. doi: Doi 10.1016/S0169-5347(98)01554-7

Fenn, M. E., Baron, J. S., Allen, E. B., Rueth, H. M., Nydick, K. R., Geiser, L., . . . Neitlich, P. (2003). Ecological effects of nitrogen deposition in the western United States. *Bioscience, 53*(4), 404-420. doi: Doi 10.1641/0006-3568(2003)053[0404:Eeondi]2.0.Co;2

Johnson, N. C. (1993). Can Fertilization of Soil Select Less Mutualistic Mycorrhizae. *Ecological Applications, 3*(4), 749-757. doi: Doi 10.2307/1942106

Kimball, S., Goulden, M. L., Suding, K. N., & Parker, S. (2014). Altered water and nitrogen input shifts succession in a southern California coastal sage community. *Ecological Applications, 24*(6), 1390-1404.

Padgett, P. E., & Allen, E. B. (1999). Differential responses to nitrogen fertilization in native shrubs and exotic annuals common to Mediterranean coastal sage scrub of California. *Plant Ecology, 144*(1), 93-101. doi: Doi 10.1023/A:1009895720067

Padgett, P. E., Allen, E. B., Bytnerowicz, A., & Minich, R. A. (1999). Changes in soil inorganic nitrogen as related to atmospheric nitrogenous pollutants in southern California. *Atmospheric Environment, 33*(5), 769-781. doi: Doi 10.1016/S1352-2310(98)00214-3

Perkins, L. B., & Nowak, R. S. (2013). Native and non-native grasses generate common types of plant-soil feedbacks by altering soil nutrients and microbial communities. *Oikos, 122*(2), 199-208. doi: DOI 10.1111/j.1600-0706.2012.20592.x

Pimentel, D., Zuniga, R., & Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics, 52*(3), 273-288. doi: DOI 10.1016/j.ecolecon.2004.10.002

Sakai, A. K., Allendorf, F. W., Holt, J. S., Lodge, D. M., Molofsky, J., With, K. A., . . . Weller, S. G. (2001). The population biology of invasive species. *Annual Review of Ecology and Systematics, 32*, 305-332. doi: DOI 10.1146/annurev.ecolsys.32.081501.114037

Steppan, S. J. (1991). Geographic-Distribution of Flower Morphological Traits in Subspecies of Lotus-Scoparius. *Journal of Biogeography, 18*(3), 321-331. doi: Doi 10.2307/284540

Effects of Parental Status on Male Body Composition and Diet Preference In the Biparental California Mouse

Lorraine R. Horwitz, Meng Zhao, and Wendy Saltzman

Department of Biology

ABSTRACT

The physiological, behavioral, and energetic costs of reproduction and parental care have been studied extensively in mammalian mothers, while few studies have examined the costs associated with paternal care in mammalian fathers. This study aimed to characterize possible energetic costs associated with fatherhood in the monogamous, biparental California mouse (*Peromyscus californicus*). Virgin males (n=14-15), males housed with tubally ligated females (non-breeding males, n=14), and new fathers (n=14-15) were weighed twice per week from pairing until the birth of their first litter (or an equivalent time period for virgin and non-breeding males). Testing began 3-5 days later. Data collected included body mass, body composition (fat and lean masses), and preference for a high-fat diet. We found no significant differences among reproductive categories in any of these measures; however, the decline in body mass across the course of the study tended to be smaller in virgin males compared to non-breeding males and new fathers, with new fathers having the largest drop in body mass. These results suggest that fathers do not have higher energetic costs than non-reproductive males in a monogamous, biparental mammal, at least under laboratory conditions. Future studies in long-term breeding males living under more challenging environmental conditions may reveal higher energetic costs associated with paternal care.

Keywords: Biparental, *Peromyscus californicus*, Body Composition, Body Mass, Diet

AUTHOR

Lorraine Horwitz

Department of Biology

Lorraine Horwitz is a fourth year Biochemistry major working in Dr. Wendy Saltzman's behavioral neuroendocrinology lab in the Department of Biology. She focuses on characterizing the energetic cost associated with fatherhood. Additionally, she studies the effects of fatherhood on animal behavior and body morphology. She plans on pursuing a career in animal research after she graduates in June 2015. Allison would like to thank the MARC U STAR program for their financial support and Meng Zhao for her guidance and knowledge.

FACULTY MENTOR

Wendy Saltzman

Department of Biology

Professor Saltzman's research focuses on the behavioral neuroendocrinology of mammalian parenting. Currently her lab investigates the neural, hormonal, and sensory mechanisms that contribute to the expression of paternal behavior, as well as possible effects of parenthood on stress responsiveness, anxiety, and physiology in fathers.

INTRODUCTION

As a female mammal transitions into motherhood, numerous physiological and behavioral changes occur that promote balance between reproductive costs and self-maintenance. These alterations are coordinated through functional changes in several systems, including the respiratory system, the cardiovascular system, the immune system and behavior (Bouman et al., 2005, Russell et al., 2001). Perhaps most importantly, the homeostatic mechanisms governing energy utilization undergo significant changes, as female mammals endure a high energetic cost of parental care due to gestation, lactation, and maternal behavior (Ladyman et al., 2010;Woodside, et al., 2012). In some species, this cost is offset by assistance from fathers.

Species in which both parents contribute to the survival of offspring (i.e., biparental species) can be found across a broad range of taxonomic groups, including birds, reptiles, and mammals. Approximately 5-10% of mammalian species are biparental, with the largest number having been identified among rodents, primates, and carnivores (Kleiman & Malcolm 1981; Woodroffe & Vincent, 1994). Biparental care in monogamous species can contribute to an increased survival rate of progeny, at a shared expense to both mother and father (Bester-Meredith & Marler, 2001; Bredy et al., 2004; Cantoni et el., 1997a,b; Dudley, 1974; Frazier et al., 2006; Gubernick & Teferi, 2000; Gubernick et al., 1993; Wright & Brown, 2002). For example, in certain rodent species, such as the monogamous prairie vole (Microtus ochrogaster), engaging in pair-bonding and parenting behavior results in costs for males, demonstrated by significant losses in body mass, fat reserves, and circulating leptin concentrations over time, even under laboratory conditions in which animals have no predation, limited space, and ad libitum food (Campbell et al., 2009). Very few studies, however, have characterized the cost of paternal care in mammals, especially over an extended period of time.

Monogamous, biparental California mice produce altricial offspring that are completely dependent upon their parents for survival. Males and females form long-term pair bonds that contribute to their lifetime reproductive success. Fathers directly influence the survival of their offspring

by performing similar parental behaviors as mothers, such as huddling, grooming and socializing pups (Dudley et al., 1974b; Gubernick et al., 1987). If the father is not present, mothers will experience a decrease in lactation and a decreased chance of pup survival (Cantoni & Brown, 1997b; Gubernick et al., 1993, 2000), indicating that paternal care of young is critical for offspring survival in this species.

In this study, we tested the hypothesis that paternal care is energetically costly in the California mouse, as determined by measures of body mass, body composition, and preference for high-fat diet in males. We predicted that males housed with either a non-reproductive female or another male would have similar body mass, body composition, and dietary preferences, while fathers would experience a loss of body mass, decrease in body fat, and increase in preference for a high-fat diet.

METHODS

Animals

Adult California mice and their offspring were obtained from our breeding colony at UCR and descended from mice purchased from the *Peromyscus* Genetic Stock Center (University of South Carolina, Columbia, SC). Mice were housed in 44 x 24 x 20 cm polycarbonate cages under standard conditions (Harris et al., 2011, Saltzman et al., in press) and had *ad libitum* access to food (Purina Rodent Chow 5001, PMU Nutrition International, St Louis, MO) and tap water. Cages were checked daily and changed weekly.

At 27-32 days of age, pups were permanently removed from their natal cage and housed in same-sex groups containing 3-4 age-matched related and/or unrelated animals. In early adulthood (≥90 days of age) mice were placed into designated testing groups (see below). Typically, pair mates were no more closely related to each other than second cousins.

Experimental Design

Forty-four adult males were randomly assigned to three groups: virgin males (VM, n=15) paired with another male, non-breeding males (NBM, n=14) housed with a tubally ligated

female (see below) and therefore unable to reproduce despite mating, and new fathers (NF, n=15) housed with a mate and subsequent offspring. Males were weighed twice each week at 15:00-17:00 h at 3- to 4-day intervals for a period of 5-9 weeks, until the birth of each father's first litter or an equivalent time point for non-reproductive males (VM and NBM). Three to five days later an 11-day testing period commenced. Body composition was assessed on test days 1 and 2, and a high-fat diet preference test was administered on day 8. All males were weighed on test days 1, 2, 4, 5, 7, 9 and 11. The period of data collection for virgin and non-breeding males was matched to that of breeding males undergoing data collection at the same time (see Fig. 1). Testing for a larger project was performed concurrently, but additional data were not included in this paper. Specific procedures are described below.
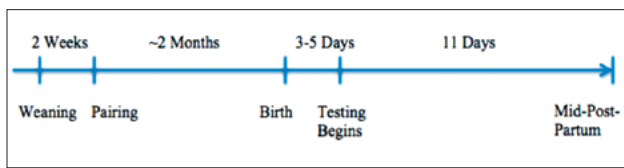
Fig. 1: *Timeline of procedures*

Tubal Ligations

Females that were to be housed with non-breeding males underwent bilateral ligation of the oviducts, as previously described (Harris & Saltzman, 2013). Females were then housed individually and allowed to recover for two weeks before being paired with a male.

Body Composition

A male was placed into an EchoMRI-100 magnetic resonance whole-body analyzer (Echo Medical Systems, Houston, TX) for about one minute without sedation or anesthesia, at approximately 17:00-18:00 h on test days 1 and 2. Lean and fat fractions of total body mass were calculated and body mass was determined just prior to MRI scanning. The average of day 1 and day 2 was used in data analysis.

High-Fat Diet Preference

During their active phase (lights off) males were placed for a 4-hour period (19:00-23:00 h) into polycarbonate cages fitted with a plastic divider across the width of the cage, while their cage mates occupied the opposite compartment. Males had access to ~40g standard chow (13.4% Kcal fat, Purina 5001 Rodent Chow, PMU Nutrition International, St Louis, MO), ~40g high-fat chow (43.5% Kcal Fat, Modified Diet 5001,Test Diet, Richmond, IN) and tap water. Food and water were weighed immediately before and after the 4-hour test period. The difference between initial and final mass of each diet was calculated with allowance for spillage.

Statistical Analysis

Analyses were completed using SPSS Statistical software (SPSS Inc., Chicago, IL) and SAS Statistical Software (SAS Inc., Cary, NC). For all tests, normality and homogeneity of variance were checked with a Levene's Test and data was transformed as necessary (see Results). ANCOVAs were used for analysis of body composition, high fat-diet preference, change in prepartum body mass, and change in prepartum to postpartum body mass. Repeated-measures ANCOVA was used for analysis of postpartum body mass. Depending on the specific analysis, covariates included age, number of days elapsed since pairing, lean mass, initial body mass, age at initial mass, and number of days between initial mass and final mass before birth of offspring (see Results). All tests were evaluated at a significance level of $p<0.05$.

RESULTS

High-fat Diet Preference

Preference for high-fat diet was calculated as the proportion of high-fat diet consumed relative to the total amount of food consumed (high-fat + standard diets) during the 4-hour test period. We performed an exponential transformation to the power of 0.3 to normalize data. ANCOVA showed that preference for high-fat diet did not differ significantly among VM, NBM and NF ($F_{2,42} = 1.01$, P= 0.37; Table 1 and Fig. 2). Overall, there was no trend for high-fat diet preference, as only 13.95% of males consumed a greater amount of high-fat
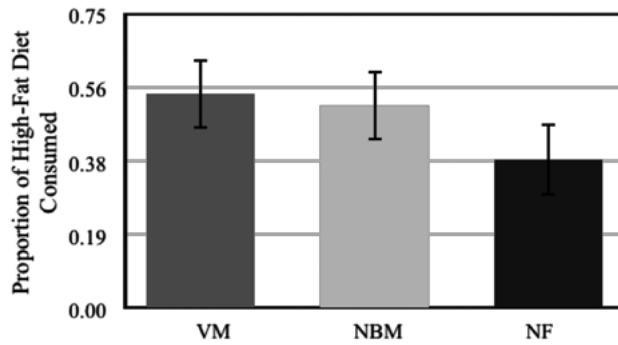
Fig. 2: Proportion of high-fat diet consumed relative to total diet consumed (mean ± standard error). Values were not significantly different among groups (P=0.37). Data were exponentially transformed to the power of 0.3.

Body Composition: Fat Mass

Fat mass (average of days 1 and 2) did not differ significantly among VM, NBM, and NF ($F_{2,43}$ = 2.45, P=0.10; see Table 1). Covariates were lean mass, age, and days from pairing. Lean mass was correlated with fat mass (P< 0.001); however, fat mass was not associated with any other variable (age, P=0.23; days from pairing, P=0.96).

Body Composition: Lean Mass

Lean mass (average of days 1 and 2) did not differ significantly among reproductive conditions ($F_{2,43}$=0.01, P= 0.99; Table 1). Covariates were age and days from pairing, and neither variable was significantly associated with lean mass (age, P=0.35; days from pairing, P= 0.06).

Change in Body Mass: Prepartum

ANCOVA showed no significant effect of reproductive condition on change in prepartum body mass ($F_{2,42}$ =2.57, P=0.09; Table 1) from the time of pairing until birth of the first litter in breeding males, or over the same time period in virgin and non-breeding males. Initial mass, age at initial mass, and number of days between initial and final mass measurements were used as covariates. Initial mass was significantly associated with change in prepartum body mass (P= 0.01), but no other covariate was a significant predictor of this change (age at initial mass, P = 0.09; number of days between initial and final mass, P = 0.58).

Body Mass: Postpartum

Repeated-measures ANCOVA showed that the seven measures of body mass after the birth of a breeding male's first litter, or the equivalent time point in non-breeding males and virgin males, did not differ significantly among groups ($F_{2,41}$ = 0.26; P=0.77), across time points ($F_{6,241}$=2.04 P= 0.06), or by a group x time point interaction ($F_{12,241}$= 0.89; P=0.06; see Table 1). Age was used as a covariate and was not a significant predictor of body mass (P=0.09).

Change in Body Mass: Overall

There was no significant effect of reproductive condition on body mass from pairing to final testing day ($F_{2,41}$ = 3.08, P= 0.058; Table 1 and Fig. 3), although P values approached significance. NF tended to show a greater drop

Reproductive Condition	VM (N=14-15)	NBM (N=14)	NF (N=14-15)	P-Values
High-Fat Diet Preference	0.55 ± 0.08	0.52 ±.0.09	0.38 ±.0.09	0.37
Body Comp: Fat Mass (g)	8.26 ±.0.58	6.91 ± 0.59	6.48 ±.0.59	0.10
Body Comp Lean Mass (g)	34.36 ±41.11	34.32 ±41.14	34.15 ±41.14	0.99
Δ Body Mass: Prepartum (g)	1.47 ±.1.26	-0.09 ±01.26	-2.53 ±21.23	0.09
Body Mass: Postpartum (g)	45.08 ±51.86	44.72 ±41.98	43.16 ±32.01	0.77 among groups 0.06 across time points 0.06 group x time point
Δ Body Mass: Overall (g)	-0.53 ±00.85	-2.35 ±20.85	-3.58 ±30.87	0.058

Table 1: High-fat diet preference, fat mass, lean mass, as well as changes in mean body mass across the prepartum period, the postpartum period, and the entire study, in virgin males (VM), non-breeding males (NBM), and new fathers (NF). Values are means ± SE, and P-values refer to among-group comparisons unless stated otherwise.

in body mass across time compared to both NBM and VM, and NBM tended to show a greater drop in body mass than VM. Initial mass, age, and number of days between initial and final mass were used as covariates. Initial mass was a significant predictor of change in prepartum to postpartum body mass (P=0.02); no other covariates were significant predictors (age, P= 0.27; number of days between initial and final mass, P=0.92).
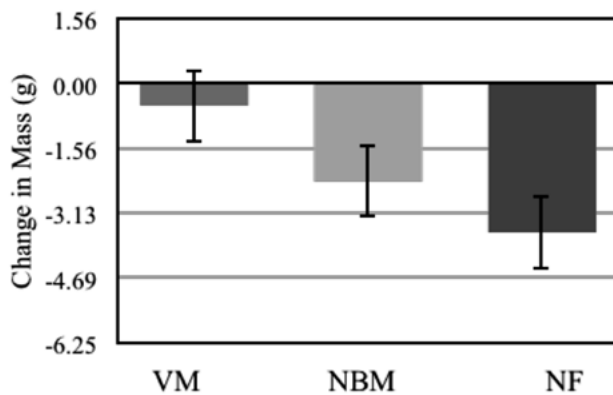
Fig. 3: *Change in body mass from prepartum initial mass to postpartum final mass (mean ± standard error). Differences among reproductive conditions approached significance (P=0.058).*

DISCUSSION

In this study, we aimed to determine the cost, if any, of paternal care through measurements of body mass, body composition (fat mass and lean mass), and preference for high-fat diet over regular diet in biparental male California mice. Our data indicate that these measures do not differ among fathers, males housed with a non-reproductive female, and males housed with another male. These results suggest that being a new father and providing care for offspring might not have pronounced energetic costs, at least under laboratory conditions.

Previous studies in male California mice demonstrated that fathers have an increase in body mass on postpartum day 30 as the first litter is weaned, followed by a systematic decrease in body mass over the course of 10 days after the second litter is born (Harris et al., 2011). Additionally, experienced fathers (1-4 previous litters) housed with pups undergo a significant increase in body mass during their mate's subsequent pregnancy, compared to fathers housed

without pups (Saltzman et al., in press). This same study demonstrated that males housed with first-time pregnant females have significantly lower body mass compared to males housed with tubally ligated females, whereas body mass did not differ between the latter group and virgin males housed with another male (Saltzman et al., in press). Similarly, in another monogamous, biparental rodent, the prairie vole, males experience significant weight loss over their mate's pregnancy and parturition, with maximum weight loss near the weaning of the first litter (Campbell et al., 2009). These findings suggest that parental experience plays a role in coordinating changes in body mass leading up to and following parturition. One possible explanation for the absence of differences between reproductive conditions in the present experiment is that, due to the lack of previous paternal experience, first-time fathers do not prepare for the energetic costs of fatherhood leading up to and following parturition of their first litter. This then might change as they prepare for the birth of subsequent litters, exhibited by an increase in body mass as their first litter is weaned and a decrease in body mass after the birth of their second litter. However, there was a slight decrease in new fathers' body mass from initial prepartum to final postpartum body mass compared to males housed with tubally ligated females, and males housed with other males. More testing is needed to determine the significance, if any, of these results.

It is difficult to characterize the overall cost of paternal care, especially in rodent species in which gestation and lactation in females occur simultaneously, because it is unknown if body-mass change is due to changes in energy expenditure and/or changes in energy intake during the mating and parenting process. We aimed to characterize this difference by administering a one-time high-fat diet preference test; the results did not differ significantly across reproductive categories. This would suggest that there is no increased preference for high-fat diet, and by extension, that energy intake is not altered by reproductive status. However, this relationship is difficult to characterize because body mass also did not change during the testing period. Future long-term studies of males with consecutive litters may be able to elucidate differences in dietary preference.

It is important to note that all experiments described were performed within a laboratory environment, in which

exposure to natural environmental stressors, such as predation, climate irregularity, and low food availability, was eliminated. A more accurate depiction of the metabolic changes and demands that occur as a result of paternal care would benefit from studies performed under natural conditions and might provide insight into the evolution of paternal care in mammals.

ACKNOWLEDGEMENTS

Bester-Meredith JK, Young LJ, & Marler CA. 1999. Species differences in paternal behavior and aggression in *Peromyscus* and their associations with vasopressin immunoreactivity and receptors. *Hormones and Behavior* 36: 25–38.

Bouman A, Heineman MJ, & Faas MM. 2005. Sex hormones and the immune response in humans. *Human Reproduction* 11: 411–423.

Bredy TW, Lee AW, Meaney MJ, & Brown RE. 2004. Effect of neonatal handling and paternal care on offspring cognitive development in the monogamous California mouse (*Peromyscus californicus*). *Hormones and Behavior* 46: 30–38.

Campbell JC, Laugero KD, Van Westerhuyzen JA, Hostetler CM, Cohen JD, & Bales KL. 2009. Costs of pair-bonding and paternal care in male prairie voles (*Microtus ochrogaster*). *Physiology and Behavior* 98: 367–373.

Cantoni D & Brown RE. 1997a. Male influence on interbirth interval in the monogamous California mouse when required to forage for food. *Annals of the New York Academy of Sciences* 807: 486–489.

Cantoni D & Brown RE. 1997b. Paternal investment and reproductive success in the California mouse, *Peromyscus californicus*. *Animal Behaviour* 54: 377–386.

Dudley, D. 1974. Paternal behavior in the California mouse, *Peromyscus californicus*. *Behavioral Biology* 11: 247-251.

Frazier CRM, Trainor BC, Cravens CJ, Whitney TK, & Marler CA. 2006. Paternal behavior influences development of aggression and vasopressin expression in male California mouse offspring. *Hormones and Behavior* 50: 699–707.

Gubernick DJ & Alberts JR. 1987. The biparental care system of the California mouse, *Peromyscus californicus*. *Journal of Comparative Psychology* 101: 169-177.

Gubernick DJ & Teferi T. 2000. Adaptive significance of male parental care in a monogamous mammal. *Proceedings of the Royal Society of London. Series B: Biological Sciences* 267: 147-150.

Gubernick DJ, Wright SL, & Brown RE. 1993. The significance of father's presence for offspring survival in the monogamous California mouse, *Peromyscus californicus. Animal Behaviour* 46: 539-546.

Harris BN, Perea-Rodriguez JP, & Saltzman W. 2011. Acute effects of corticosterone injection on paternal behavior in California mouse (*Peromyscus californicus*) fathers. *Hormones and Behavior* 60: 666–675.

Harris BN & Saltzman W. 2013. Effect of reproductive status on hypothalamic-pituitary-adrenal (HPA) activity and reactivity in male California mice (*Peromyscus californicus*). *Physiology and Behavior* 112: 70-76.

Kleiman DG & Malcolm JR. 1981. The evolution of male parental investment in mammals. In *Parental Care in Mammals:* 347–387. Gubernick, D.J. & Klopfer, P.H. (Eds). New York: Plenum.

Ladyman SR, Augustine RA, & Grattan DR. 2010. Hormone interactions regulating energy balance during pregnancy. *Journal of Neuroendocrinology* 22: 805–817.

Russell JA, Douglas AJ, & Ingram CD. 2001. Brain preparations for maternity-adaptive changes in behavioral and neuroendocrine systems during pregnancy and lactation. An overview. *Progress in Brain Research* 133: 1–38.

Saltzman W, Harris BN, de Jong TR, Nguyen PP, Cho JT, Hernandez M, & Perea-Rodriguez JP. 2015. Effects of parental status on male body mass in the monogamous, biparental California mouse. *Journal of Zoology* 2: in press.

Woodroffe R & Vincent A. 1994. Mother's little helpers: patterns of male care in mammals. *Trends in Ecology & Evolution* 9: 294–297.

Woodside B, Budin R, Wellman MK, & Abizaid A. 2012. Many mouths to feed: the control of food intake during lactation. *Frontiers in Neuroendocrinology* 33: 301–314.

Wright SL & Brown RE. 2002. The importance of paternal care on pup survival and pup growth in *Peromyscus californicus* when required to work for food. *Behavioural Processes* 60: 41–52.

Group Sequential Clinical Trials for Gamma Distributions

Kenneth S. Hsu, Daniel Jeske

Department of Satistics

ABSTRACT

Clinical trials often measure response variables that are non-negative and exhibit skewness, and gamma distributions are a good modeling choice for this type of variable. In this paper, an algorithm is developed to design a sequential clinical trial where the response variable follows a gamma distribution. The clinical trial design allows the determination of whether or not two independent gamma distributions are the same, while controlling the classical type-I and type-II error rates. The computational algorithm is implemented in R and is based on an optimization strategy that involves the combined use of a bisection root finding scheme and Monte Carlo integration. Look-up tables are provided that will enable most practitioners to design their experiments easily. The reduced average sample number properties of a sequential design compared to a fixed sample design are illustrated.

Keywords: clinical trials, error spending functions, gamma distribution, sample size determination, sequential analysis, statistics

FACULTY MENTOR

Daniel Jeske

Department of Statistics

Daniel R. Jeske is Professor and Chair in the Department of Statistics at the University of California, Riverside. His research interests include classification and clustering methodologies, statistical process control algorithms, and clinical trials. He is the Director of the department's statistical consulting collaboratory, an elected Fellow of the American Statistical Association and a member of the Board of Directors of the American Statistical Association. Before joining UCR, he was a Distinguished Member of the Technical Staff, and a Technical Manager, at AT&T Bell Laboratories.

AUTHOR

Kenneth Hsu

Department of Statistics

Kenneth is a fourth year statistics major and computer science minor. He is the President of the Highlander Statistics Society and Treasurer of Mu Sigma Rho, a national honorary society for statistics students. He is passionate about how computer algorithms can be manipulated to understand the field of statistics and applied mathematics. His research with Dr. Jeske focused on designing sequential clinical trials for gamma distributions. He plans to pursue a graduate degree in actuarial science in hopes of becoming an actuary.

1. INTRODUCTION

1.1 Fixed Sample Size in Clinical Trials

The main purpose of a clinical trial is to evaluate the effectiveness of a proposed treatment regimen. Details such as the null hypothesis (H_0), alternative hypothesis (H_1), type-I error (α) and type-II error (β), are specified before the trial begins. The sample size must also be determined before carrying out the experiment. Finding the sample size for a fixed sample size clinical trial is widely discussed in the literature. See, for instance, "Fundamentals of Clinical Trials" (Friedman 133). If the observations are normally distributed, then the sample size (n) for each group for a two-sided test could be determined based on the potential difference in means (Δ) we wish to detect, the populations' common standard deviation (σ), α, and β with the formula $n = \sigma^2(z_{\alpha/2} + z_\beta)^2 / \Delta^2$, where the z values denote the upper percentiles of a standard normal distribution (Kraemer 39).

1.2 Group Sequential Analysis in Clinical Trials

Suppose one would like to design an experiment to see if the means of two groups differ from each other ($H_1 : \mu_X \neq \mu_Y$) using a sequential experiment. In the context of normal distributions, the sample size needed for each group at each stage to reach the pre-specified power ($1 - \beta$) is discussed thoroughly by Jennison and Turnbull in "Group Sequential Methods with Applications to Clinical Trials"; however, the designs discussed are not applicable to situations where samples are not normally distributed (Jennison 147). Consider, for example, data involving time such as illness recovery time or survival time. How can a similar experimental design be developed for non-negative distributions, specifically, for gamma distributions? We will explore how this change in distributions impacts the design of the decision boundaries needed for the study, particularly, where the experiment involves only two stages.

2. PRELIMINARIES

A researcher would like to analyze the effectiveness of a new drug that was designed to help a patient recover from an illness. Suppose that each patient's recovery time is independently and identically gamma distributed with known shape (r) and scale (λ) parameters. Assume the shape parameters are the same, and interest lies in finding out if there is a difference between the scale parameters of the new drug and the currently used drug. In other words, we would like to determine if a difference exists in mean recovery time between the treatment group (new drug) and the control group (currently used drug).

We will parameterize the density function of a gamma distribution as follows, $f(x) = \dfrac{1}{\Gamma(r)(\lambda)^r} x^{r-1} e^{\frac{-x}{\lambda}}$. Note that its mean ($\mu$) is $r\lambda$, and variance (σ^2) is $r\lambda^2$. Patients will be allocated into two groups corresponding to control (X) and treatment (Y), respectively. We are interested in the ratio of the scale (λ) parameters for the two gamma distributions. We will use ρ ($= \lambda_X / \lambda_Y$) to denote the ratio between the two scale parameters, and ρ_1 to be the chosen value of ρ for which we want power to be $1 - \beta$. We will use m to denote the number of samples needed from each group at each stage. In summary, we have,

Stage one:

control: $X_{11}, X_{12}, ..., X_{1m} \overset{i.i.d}{\sim} \text{Gamma}(r, \lambda_X)$

treatment: $Y_{11}, Y_{12}, ..., Y_{1m} \overset{i.i.d}{\sim} \text{Gamma}(r, \lambda_Y)$

Stage two (only if needed):

control: $X_{21}, X_{22}, ..., X_{2m} \overset{i.i.d}{\sim} \text{Gamma}(r, \lambda_X)$

treatment: $Y_{21}, Y_{22}, ..., Y_{2m} \overset{i.i.d}{\sim} \text{Gamma}(r, \lambda_Y)$

If we stop at stage one, the total number of samples needed would be $2m$. However, if we need to go onto stage two, $4m$ samples would be needed and a conclusion will be deduced.

We will utilize the method of error spending functions. We choose an α and β that we desire to attain for the study; however, we will only spend a fraction of the overall α and β in each stage, hence, the name of "error spending functions". We will begin the study with the most common α and β level, 0.05 and 0.20, respectively. We also note that the selected partition of α

and β is not completely arbitrary for the designs we are discussing. For some partitions, the ordering of the decision boundaries may not conform to the decision boundaries diagrams. In these cases, either a different partition should be selected, or, a different experimental design should be used. We will use the notation α_1 for the portion of α to be spent in stage one, and α_2 for the portion spent in stage two; similarly, β_1 and β_2. Note the equalities $\alpha = \alpha_1 + \alpha_2$ and $\beta = \beta_1 + \beta_2$ are established.

We denote sums of the observations in the control group as follows,

Stage one:

$$X_{1\cdot} = X_{11} + X_{12} + ... + X_{1m} = \sum_{i=1}^{m} X_{1i}$$

Stage two (only if needed):

$$X_{2\cdot} = X_{21} + X_{22} + ... + X_{2m} = \sum_{i=1}^{m} X_{2i}$$

Note that $X_{2\cdot}$ only contains data values from stage two; it does not include data from stage one; similarly, for $Y_{1\cdot}$ and $Y_{2\cdot}$. We will define the test statistics F as follow:

Stage one:

$$F_1 = \frac{X_{1\cdot}}{Y_{1\cdot}} = \frac{\sum_{i=1}^{m} X_{1i}}{\sum_{i=1}^{m} Y_{1i}}$$

Stage two (only if needed):

$$F_2 = \frac{X_{1\cdot} + X_{2\cdot}}{Y_{1\cdot} + Y_{2\cdot}} = \frac{\sum_{i=1}^{m} X_{1i} + \sum_{i=1}^{m} X_{2i}}{\sum_{i=1}^{m} Y_{1i} + \sum_{i=1}^{m} Y_{2i}}$$

3. ONE-SIDED TESTS

3.1 Decision Boundaries

Suppose we are interested in finding out if the new drug is better at reducing patients' recovery times; meaning, the mean recovery time of the treatment group is lower than the mean of the control group. Then our hypothesis will be $H_0 : \rho \leq 1$ versus $H_1 : \rho > 1$.

In stage one, we will use two critical values to determine if we can accept or reject our null hypothesis. If we need more information, we will move on to stage two and use one critical value to determine if we should accept or reject our null hypothesis as this is the final stage of the study. The reasoning for these constants' setup is as follows. If the test statistic is too large, that suggests that the treatment group's mean is lower and we should reject the null hypothesis and conclude that the treatment does indeed reduce patient recovery time. Similarly, if the test statistic is too small, that means that the treatment group's mean is larger than the control group's mean and in turn we should accept the null hypothesis.

We denote the three critical values as a_1, r_1, and d. Our decision rules will be as follow:

Stage one:

$$\begin{cases} r_1 < F_1, \text{ reject } H_0 \\ a_1 < F_1 < r_1, \text{ move to stage 2} \\ F_1 < a_1, \text{ accept } H_0 \end{cases}$$

Stage two:

$$\begin{cases} d < F_2, \text{ reject } H_0 \\ F_2 < d, \text{ accept } H_0 \end{cases}$$

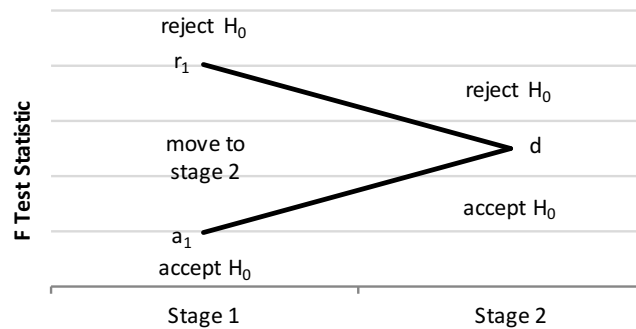Figure 1 summaries the decision boundaries setup in a graphical representation.

Figure 1. *Decision boundaries setup for a one-sided test.*

Besides the decision boundaries, we will need to find m, the number of samples needed from each group in each stage. We will also use the fact that $2X_{1\cdot} / \lambda_X$, $2X_{2\cdot} / \lambda_X$, $2Y_{1\cdot} / \lambda_Y$ and $2Y_{2\cdot} / \lambda_Y$ all follow a chi-square distribution with degrees of freedom $2mr$ (Wackerly 185). Because the quotients of two chi-square distributions follow an F-distribution, we will compare the two group's sum with an F statistic (Wackerly 322). Namely,

$$\frac{2X_{1\cdot} / \lambda_X}{2Y_{1\cdot} / \lambda_Y} = \frac{\lambda_Y}{\lambda_X} \frac{X_{1\cdot}}{Y_{1\cdot}} = \frac{1}{\rho} F_1 \sim F_{2mr, 2mr}.$$

If there is no difference in the mean between the two groups, $\rho = 1$, then we can use F_1 as our test statistics in stage 1.

Stage two has a similar setup because the sum of two chi-square distributions still follows a chi-square distribution with degrees of freedom equal to the sum of the two chi-square distributions being summed (Casella 511). Namely,

$$\frac{(2X_{1.} + 2X_{2.})/\lambda_X}{(2Y_{1.} + 2Y_{2.})/\lambda_Y} = \frac{\lambda_Y}{\lambda_X}\frac{X_{1.} + X_{2.}}{Y_{1.} + Y_{2.}} = \frac{1}{\rho}F_2 \sim F_{4mr,4mr}.$$

If there is no difference in the mean between the two groups ($\rho = 1$), then we can use F_2 as our test statistics.

Recalling the error spending functions mentioned previously, we could then set up equations, under each hypothesis, as follows:

$$\begin{cases} \alpha_1 = P_{H_0}(r_1 < F_1) \\ \alpha_2 = P_{H_0}((a_1 < F_1 < r_1) \cup (d < F_2)) \\ \beta_1 = P_{H_1}(F_1 < a_1) \\ \beta_2 = P_{H_1}((a_1 < F_1 < r_1) \cup (F_2 < d)) \end{cases} \quad (1)$$

Note that in the first and second equations in (1) we have $F_1 \sim F_{2mr,2mr}$ and $F_2 \sim F_{4mr,4mr}$, while in the third and fourth equations we have $F_1/\rho_1 \sim F_{2mr,2mr}$ and $F_2/\rho_1 \sim F_{4mr,4mr}$. With that, we will have four equations, and four unknowns, a_1, r_1, d, and m in a system of equations.

3.2 Computations and Algorithm

The system of four equations (1) has no closed form solution. However, two numerical methods can be used to obtain a close approximation. The first numerical method approximates the integrals using Monte Carlo integration techniques (Givens 143). The second numerical method finds roots of an equation using the bisection method (Burden 48). We introduce a new variable v, where $v = mr$ to help us generalize the algorithm. If we know v, we can get m for any r using $m = v/r$.

The algorithm is as follows:

i. Given α_1, α_2, β_1, β_2, and ρ_1, the algorithm begins by initializing v to 1.

ii. Use the first and third equations in (1) to solve for $r_1 = F_{2v,2v,\alpha_1}$ and $a_1 = \rho_1 F_{2v,2v,1-\beta_1}$.

iii. Use the second equation in (1) and the bisection algorithm to solve for d, with (a_1, r_1) as the initial bracketing interval.

iv. Use the fourth equation in (1) to check if the current v is correct. If it is not correct, increment v and repeat steps (ii)-(iv).

v. Calculate m with $m = v/r$, and rounding it up to the nearest integer.

4. TWO-SIDED TESTS

4.1 Decision Boundaries

Suppose now we are interested in finding out if the new drug differs from the control in either direction. Our hypothesis will be $H_0 : \rho = 1$ versus $H_1 : \rho \neq 1$.

In stage one, we will need four critical values to determine if we can accept or reject our null hypothesis; if we need more information, we will move on to stage two. In stage two, we will use two critical values to determine if we should accept or reject our null hypothesis. The reasoning for these constants' setup is as follows. Recall that we are interested in the ratio of the mean of the two populations. If the test statistic were too large or too small, that would suggest that the two means differ from each other and we should reject the null hypothesis. Otherwise, if the test statistic is moderate, then we should accept the null hypothesis and conclude that the means of two groups are not significantly different from each other. Values in stage one that fall between these magnitudes correspond to the continuation region. Our decision rules will be as follows:

Stage one:

$$\begin{cases} r_{1U} < F_1, \text{ reject } H_0 \\ a_{1U} < F_1 < r_{1U}, \text{ move to stage} \\ a_{1L} < F_1 < a_{1U}, \text{ accept } H_0 \\ r_{1L} < F_1 < a_{1L}, \text{ move to stage} \\ F_1 < r_{1L}, \text{ reject } H_0 \end{cases}$$

Stage two:

$$\begin{cases} d_U < F_2, \text{ reject } H_0 \\ d_L < F_2 < d_U, \text{ accept } H \\ F_2 < d_L, \text{ reject } H_0 \end{cases}$$

Figure 2 summaries the decision boundaries setup in a graphical representation.
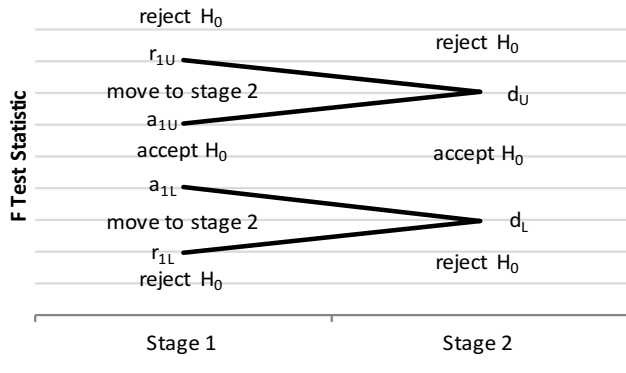
Figure 2. *Decision boundaries setup for a two-sided test*

Furthermore, we will need to find m, the number of samples needed from each group in each stage. We will use the same test statistics, F_1 and F_2, and incorporate them to solve for the decision boundaries. With the error spending functions previously mentioned, we can set up equations under each hypothesis as follows:

$$
\begin{cases}
\alpha_1 = P_{\rho=1}\left(F_1 > r_{1U} \cup F_1 < r_{1L}\right) \\
\alpha_2 = P_{\rho=1}\left(\left(\left(r_{1L} < F_1 < a_{1L}\right) \cup \left(a_{1U} < F_1 < r_{1U}\right)\right) \cap \left(\left(F_2 < d_L\right) \cup \left(d_U < F_2\right)\right)\right) \\
\beta_1 = P_{\rho=\rho_1}\left(a_{1L} < F_1 < a_{1U}\right) \\
\beta_2 = P_{\rho=\rho_1}\left(\left(\left(r_{1L} < F_1 < a_{1L}\right) \cup \left(a_{1U} < F_1 < r_{1U}\right)\right) \cap \left(d_L < F_2 < d_U\right)\right)
\end{cases}
\tag{2}
$$

Similar to the one-sided scenario, in the first and second equations in (2) we have $F_1 \sim F_{2mr,2mr}$ and $F_2 \sim F_{4mr,4mr}$, while in the third and fourth equations we have $F_1/\rho_1 \sim F_{2mr,2mr}$ and $F_2/\rho_1 \sim F_{4mr,4mr}$.

4.2 Computations and Algorithm

We will find r_{1U} and r_{1L} such that the area under the density function of $F_{2mr,2mr}$ from $x = 0$ to $x = r_{1L}$ and from $x = r_{1U}$ to $x = \infty$ sum to α_1, and such that r_{1U} and r_{1L} have the same probability density value. Similarly, we will find a_{1L} and a_{1U} such that the area under the density function from $x = a_{1L}$ to $x = a_{1U}$ is β_1, and that a_{1L} and a_{1U} has equal probability density. For α_2, the second equation in (2), we will use the equal tail choice method to breakdown the equation into two parts:

$$
\begin{aligned}
\alpha_2 = & P_{\rho=1}\left(\left(\left(r_{1L} < F_1 < a_{1L}\right) \cup \left(a_{1U} < F_1 < r_{1U}\right)\right) \cap \left(F_2 < d_L\right)\right) \\
& + P_{\rho=1}\left(\left(\left(r_{1L} < F_1 < a_{1L}\right) \cup \left(a_{1U} < F_1 < r_{1U}\right)\right) \cap \left(d_U < F_2\right)\right)
\end{aligned}
\tag{3}
$$

The steps of the algorithm used to derive the decision boundaries are as follow:

i. Given α_1, α_2, β_1, β_2, and ρ_1, the algorithm begins by initializing v to 2. If v was initialized to 1, the probability density function of the F-distribution becomes a monotonic decreasing function, hence, no respective solutions would be found in steps (ii) and (iii).

ii. Use the first equation in (2) and the method described above to solve for r_{1U} and r_{1L}.

iii. Use the third equation in (2) and the method described above to solve for a_{1L} and a_{1U}.

iv. We use the first term of (3) to solve for d_L using a bisection method with $\left(r_{1L}, a_{1L}\right)$ as the initial bracketing interval.

v. We use the second term of (3) to solve for d_U using a bisection method with $\left(a_{1U}, r_{1U}\right)$ as the initial bracketing interval.

vi. Use the fourth equation in (2) to check if v is correct. If it is not correct, increment v and repeat steps (ii)-(vi).

vii. Calculate m with $m = v/r$ and rounding it up to the nearest integer.

5. Tables

The tables are constructed using the most popular α and β, 0.05 and 0.20, respectively. In the following tables, we will spend 40% of each error rate in stage one and the remaining in stage two to protect against being overly aggressive in trying to minimize the sample size. In other words, our error spending function used is $\alpha_1 = 0.02$, $\alpha_2 = 0.03$, $\beta_1 = 0.08$, and $\beta_2 = 0.12$. The tables provide the decision boundaries and v. The sample size needed for each group in each stage, m, is calculated as $m = v/r$, where r is the assumed shape parameter of the gamma distribution. The value of ρ_1 will affect the decision boundaries and the sample size; therefore, the algorithm must be rerun for values of ρ_1 not listed in the table.

5.1 One-Sided Table

Decision Boundaries	ρ_1					
	1.05	1.1	1.2	1.3	1.4	1.5
α_1	1.0115	1.0227	1.0442	1.0633	1.0826	1.1002
r_1	1.0561	1.1124	1.2256	1.3419	1.4571	1.5747
d	1.0328	1.0651	1.1282	1.1885	1.2479	1.3035
v	2827.5	744.19	204.50	98.157	60.124	41.516

Table 1. A look-up table for the one-sided test.
$\alpha = 0.05$ and $\beta = 0.20$ ($\alpha_1 = 0.02$, $\alpha_2 = 0.03$, $\beta_1 = 0.08$, and $\beta_2 = 0.12$)

5.1 Two-Sided Table

Decision Boundaries	ρ_1					
	1.05	1.1	1.2	1.3	1.4	1.5
r_{1L}	0.9500	0.9027	0.8202	0.7453	0.6813	0.6249
a_{1L}	1.0472	1.0932	1.1821	1.2664	1.3467	1.4234
a_{1U}	1.0518	1.10280	1.2019	1.2973	1.3893	1.4779
r_{1U}	1.0516	1.1035	1.2028	1.3040	1.4003	1.4949
d_L	0.9685	0.9393	0.8855	0.8335	0.7939	0.7631
d_U	1.0319	1.0639	1.1266	1.1834	1.2424	1.3015
v	4202.0	1077.0	298.12	141.06	86.082	59.520

Table 2. A look-up table for the two-sided test.
$\alpha = 0.05$ and $\beta = 0.20$ ($\alpha_1 = 0.02$, $\alpha_2 = 0.03$, $\beta_1 = 0.08$, and $\beta_2 = 0.12$)

6. Discussion

The tables in section 5 provide decision boundaries and sample size needed in each stage for each group for some illustrative one-sided and two-sided tests. These tables allow most practitioners to design their sequential experiments using the most popular type-I and type-II error rates. In cases where the tables are not sufficient for an experimenter, and R program has been written to automate the calculations. Tutorial examples and user's manual are available via the Department of Statistics at University of California, Riverside. For details concerning the programing language, R, see "Computational Statistics: An Introduction to R" (Sawitzki 59).

We will now demonstrate the advantages of sequential clinical trials compared to fixed sample size clinical trials. Table 3 shows the average sample number (ASN) of one-sided and two-sided tests with $r = 1$ and $\rho_1 = 1.5$. For fixed sample trials, ASN is derived to similar to what was reviewed in section 1.1 in the case of normal distributions. For sequential trials, ASN is calculated as function of stopping after the first stage where the sample size is $2m$ and progressing to the second stage where the sample size is $4m$.

One-Sided			
True ρ	1.0	1.5	2.0
Fixed Sample Trials	152	152	152
Sequential Trials	109	126	95

Two-Sided			
True ρ	0.5	1	1.5	2
Fixed Sample Trials	176	176	176	176
Sequential Trials	132	235	169	124

Table 3. Average sample size comparison between fixed and sequential trails using the design of $\rho_1 = 1.5$

In the one-sided example, where the treatment is thought to only be potentially superior and not possibly inferior, the sequential design has a smaller average sample size no matter what the magnitude of the treatment effect might be. From an ethical point of view, this implies that the experimental trial can be stopped sooner and all the patients can receive the superior treatment. In the two-sided example, where there is no prior knowledge about the potential direction of the treatment effect, we see the familiar trade-off between fewer samples needed for extreme departures in exchange for more samples needed for alternatives close to the null (Jennison 33). From an ethical point of view, this trade-off is an advantage because it allows an earlier decision to use the superior treatment for everyone, or alternatively, stop using the inferior treatment entirely. Further study can explore how the experiment involves more than 2 stages or how different partitions of the error spending functions will affect this sequential trial's design.

REFERENCES

Burden, Richard L., and J. Douglas. Faires. *Numerical Analysis*. Boston, MA: Prindle, Weber & Schmidt, 1985. Print.

Casella, George, and Roger L. Berger. *Statistical Inference*. Australia: Thomson Learning, 2002. Print.

Friedman, Lawrence M., Curt Furberg, and David L. DeMets. *Fundamentals of Clinical Trials*. New York, NY: Springer, 2010. Print.

Givens, Geof H., and Jennifer A. Hoeting. *Computational Statistics*. Hoboken, NJ: Wiley-Interscience, 2005. Print.

Jennison, Christopher, and Bruce W. Turnbull. *Group Sequential Methods with Applications to Clinical Trials*. Boca Raton: Chapman & Hall/CRC, 2000. Print.

Kraemer, Helena Chmura., and Sue Thiemann. *How Many Subjects?: Statistical Power Analysis in Research*. Newbury Park: Sage Publications, 1987. Print.

Sawitzki, Günther. *Computational Statistics: An Introduction to R*. Boca Raton: CRC, 2009. Print.

Wackerly, Dennis D., William Mendenhall, and Richard L. Scheaffer. *Mathematical Statistics with Applications*. Belmont, CA: Thomson Brooks/Cole, 2008. Print.

Effects of Housing at Differential Temperatures on Energetics and Performance in the California Mice

Allison Ibarra, Jacob Andrew, Wendy Saltzman

Department of Biology

ABSTRACT

Energetic costs of thermogenesis and locomotion have been shown to be largely additive in small mammals. At cold temperatures resources must be allocated between thermogenic and locomotor needs. Our study tested the hypothesis that several morphological and performance measures (body mass, maximum aerobic energy utilization [VO_2max], and maximum sprinting speed) would be altered in animals housed at cold temperatures compared to those housed at standard temperatures. Male California mice (*Peromyscus californicus*) were placed into two different housing conditions: at a standard temperature of 23°C (N=29) or at a cold temperature of 5°C (N=29). The mice were acclimated to their housing temperature for two weeks before testing. On each of two consecutive days, male mice underwent a VO_2max test once and a sprint-speed test once at approximately 23°C. The body mass of the mice was also determined each day. There was no significant difference in body mass or sprint speed between housing conditions. Mice housed at cold temperatures had significantly higher VO_2max when controlling for body mass of the animals ($p < 0.05$). These results suggest that housing at cold temperatures increases maximal energy expenditure during exercise but does not necessarily alter body mass or sprint performance. Future work will be done using magnetic resonance imaging to determine if housing at cold temperatures changes the muscle-to-fat ratio and whether this change would affect performance.

Keywords: energetics, cold, VO_2max, sprint, California mice, performance

AUTHOR

Allison Ibarra

Department of Biology

Allison Ibarra is a fourth year student majoring in Biological Sciences. Allison studies hormonal and physiological effects of paternal behavior. After graduation, Allison plans to pursue a doctorate. Allison would like to thank the Marc U Star program, Dr. Saltzman, and the graduate students in the Saltzman lab for their continual support and guidance. Allison would also like to thank the NIH and NSF for their financial support.

FACULTY MENTOR

Wendy Saltzman

Department of Biology

Professor Saltzman's research focuses on the biology of parental care by mammalian fathers. Currently her lab is investigating neural, hormonal, and experiential influences on paternal care, as well as effects of parenthood on behavior, brain function, stress responsiveness, and physiology in fathers.

INTRODUCTION

Performance is the ability of an individual to conduct a task when maximally motivated (Careau and Garland, 2012). It can be broken down into two main components: dynamic performance and regulatory performance (Careau and Garland, 2012). Dynamic performance is movement of all or part of the body, while regulatory performance measures how organisms regulate physiological processes of all or part of the body (Careau and Garland, 2012). Researchers have described the energetics of locomotion in a wide range of mammals at near-thermoneutral temperatures (optimal temperature at which the least amount of O_2 is consumed for metabolism), but less work has been done at colder temperatures (Chappell et al. 2004).

Life history theory proposes that allocating resources to some organismal processes (e.g. digestion, growth) limits the amount of resources available for other processes (e.g. reproduction) (Stearns, 1992). Separately, each process can demand high energy expenditure for oxygen metabolism, but at low temperatures energetic demands for both occur simultaneously. In large mammals, such as humans, and other animals, such as birds, heat produced as a byproduct of exercise can substitute for heat that would otherwise have to be produced via shivering or non-shivering thermogenesis to maintain thermoregulation in cold temperatures (Paladino and King 1984; Brooks and Fahey 1984). However, studies have suggested that in small mammals exercise heat cannot be substituted for thermogenic heat, as in larger mammals, and their costs are mainly additive (Wunder, 1970; Hart, 1971). Another factor is that the main source of heat for thermogenesis is skeletal muscles, which are also utilized for locomotor activities. (Chappell and Hammond, 2003). Therefore, these muscles, as well as the central organs that supply them with oxygen and fuel, must be allotted between thermogenic and locomotor needs (Chappell and Hammond, 2003).

Although thermogenic and locomotor costs appear to be largely additive, previous studies largely deal with submaximal exercise in many small mammals; little is known about their interaction during maximal exercise.

In this study we tested the hypothesis that differential housing temperatures will have an effect on the maximal performance of male California mice, *Peromyscus californicus*. Males were housed in either cold or standard temperature. The mice were then tested for their maximum volume of aerobic oxygen consumption (VO_2max) and maximum sprint velocity. Finally, mice were weighed to evaluate possible changes in morphology due to the differential housing temperatures. We predicted that mice housed in cold temperatures would have lower mass, higher VO_2max, and a lower maximum velocity due to the increased energy demands from living in cold conditions.

METHODS

Animals

Male California mice (N=58) were born in the breeding colony at the University of California, Riverside, which consists of descendants of mice that were purchased from the University of South Carolina Peromyscus Genetic Stock Center. At postnatal day 28-32, males were weaned and put into groups of 3-4 age-matched males. All mice were housed in polycarbonate cages (44cm x 24cm x 20cm) that contained wood-chip bedding and cotton. Lights were on a 14L:10D cycle (lights on at 0500 h), and mice had ad lib access to chow (Purina 5001 Rodent Diet) and water throughout the experiment.

All experimental procedures were performed in accordance with the Guide for the Care and Use of Laboratory Animals and were approved by the UCR Institutional Animal Care and Use Committee. All efforts were made to minimize animal suffering and numbers of animals used. UCR is fully accredited by the Association for Assessment and Accreditation of Laboratory Animal Care.

Experimental Design

Adult male California mice were randomly split into two groups. Twenty-nine males were housed at a standard temperature of approximately 23°C at approximately 65% humidity, and 29 were housed at 5°C at approximately 65% humidity. Males were housed in their respective

conditions for 2 weeks before testing. On each of two consecutive days, male mice underwent a VO_2 max test once at 10:00 h and a sprint-speed test at 14:00 h. Mice were weighed on an electric scale on each day before the VO_2max test was conducted. All tests were performed at approximately 23°C.

VO_2max

VO_2max is used to determine the maximum volume of oxygen the mice can utilize during peak exercise. Exercise VO_2 max was measured in an enclosed running wheel with controlled airflow and airtight bearings, as described previously (Chappell, 1995). The wheel was made of aluminum and acrylic with a thin carpet inside to serve as grip for a running track and injury projection. The internal volume of the wheel was 9L with an inside diameter of 32cm and width of 11cm, yielding a circumference of 1m. Speed of rotation was controlled by hand. Airflow rates were 3.5-5.5mL/min at standard temperature and pressure, depending on the mass of the animal. The connected Macintosh computer recorded and displayed O_2 concentration and flow rate every 2s.

Mice were placed in the wheel and allowed 2-3 minutes to acclimate while the resting volume of O_2 consumption and baseline O_2 concentrations were measured by comparing the volume of O_2 that entered the wheel relative to the volume of O_2 that left the wheel. Rotation of the wheel was then started and was gradually increased while VO_2max was monitored continuously. VO_2max was assumed to have been reached when VO_2 no longer increased or when mice no longer maintained position in the wheel. The exercise VO_2max was computed as the highest VO_2 averaged over 1- and 2-minute intervals, with the higher value of the two days used for analysis.

Maximum Sprint Running Speed

Maximum sprint running speed was measured as the time to cross 5.5m using an 8m long track, as described previously (Chappell, 2004). The track was a 16.5cm wide photocell-timed racetrack with a thin rubber bottom for grip. Each mouse was placed in the 38cm start area before the first photocell at the start of the procedure. Twelve sets of photocells were spaced at 0.5m intervals along the track

and were interfaced to a microcomputer that recorded all time intervals. Each California mouse was timed using the photocells lining the track, while being prodded by a lightly padded meter stick to maximize speed. After each run, the mouse was prodded to return to the start of the track, to minimize stress from being handled.

On the first day that a mouse underwent the procedure, it was prodded to walk up and down the track twice. The mouse was then run five times in quick succession, and the maximum speed was taken as time to traverse a 1.0m interval (3 sets of photocells) recordings. On the second day the mouse was walked up and down the track once. The mouse was then run five times in quick succession and the maximum velocity was taken as time to traverse a 1.0m interval (3 sets of photocells) recording during each run.

Data Analysis

Data were analyzed using JMP 10 for Macintosh (JMP Statistical Discovery from SAS, Cary, NC). Body mass, maximum sprint speed, and VO_2max were compared between cold- and standard-housed groups using unpaired t-tests. Mass was found to be significantly correlated to VO_2max; therefore, to account for this correlation, VO_2max divided by mass was analyzed. Correlational analyses were performed using Spearman's correlations.

RESULTS

Body Mass

Housing in standard vs. cold temperatures did not have a statistically significant effect on male body mass. On the first day of testing, body mass of males in the standard condition (40.13 ± 1.59 g) did not differ from that of males housed in the cold condition (39.01 ± 0.87 g; $t = 0.625$, $p = 0.535$,). Similarly, on the second day of testing, standard-housed males (40.31 ± 1.52 g) were no different in mass than cold-housed males (38.91 ± 0.85g; $t = 0.693$, $p = 0.492$).

Maximum Oxygen Consumption (VO_2max)

Across both temperature conditions, male body mass significantly correlated with VO_2max for both days of testing

(Day 1: $r^2 = 0.373$, $n=58$, $p < 0.0001$; Day 2: $r^2 = 0.229$, $n=58$, $p = 0.0005$). When correcting for body mass and taking the highest VO$_2$max reached on the two days of testing, males from the cold condition had significantly higher VO$_2$max than standard-condition males ($t = 18.043$, $p < 0.001$; Fig. 1).

Maximum Sprint Speed

Unlike VO$_2$max, sprint speed did not correlate significantly with mass on the first day of testing ($r^2 = 0.019$, $n = 58$, $p = 0.324$) but did on the second day ($r^2 = 0.076$, $n = 58$, $p = 0.03$). Using the maximum sprint speed reached on the two days of testing, when correcting for body mass, maximum sprint speed was not significantly different between standard- and cold-housed males ($t = 1.547$, $p = 0.128$; Fig. 2).
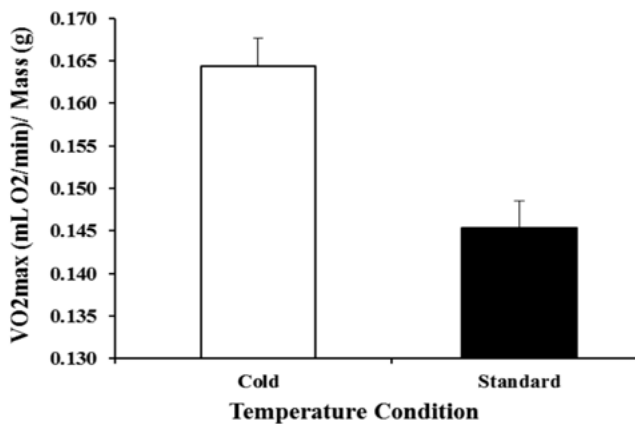
Figure 1. *Highest VO$_2$max recorded (mean + standard error), corrected for body mass, in males housed in cold and standard temperature conditions. Cold-housed animals had significantly higher VO$_2$max than standard-housed animals (p < 0.001).*
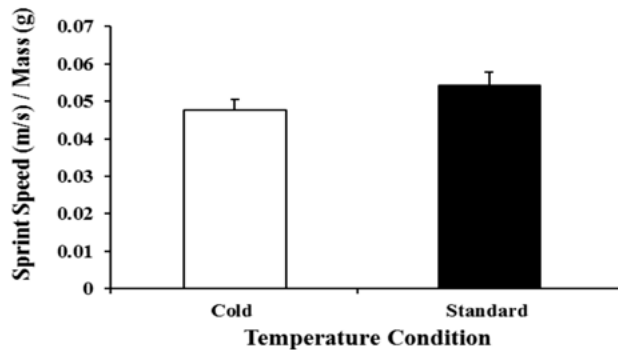
Figure 2. *Highest sprint speed (mean + standard error) corrected for body mass, recorded on the two days of testing in males housed in cold and standard temperature conditions. Sprint speed was not significantly different between temperature conditions when corrected for mass (p = 0.128).*

DISCUSSION

In this study we tested the hypothesis that differential housing temperatures would have an effect on the body mass and maximal performance of male California mice. We predicted that housing in cold temperatures would cause a decrease in body mass, an increase in VO$_2$max, and a decrease in maximum sprint speed. We found no significant difference in body mass and sprint speed between the cold-housed and standard-housed mice. We did, however, find a significant increase in VO$_2$max in mice that were housed in the cold compared to mice that were housed at standard temperature.

Body Mass

We originally predicted that mice housed in cold conditions would have lower body mass than mice housed at standard conditions. However, we did not find any significant difference in mass between the two housing conditions. In previous studies, rats (*Rattus norvegicus*) that were cold-adapted showed a large decrease in body weight during cold exposure (Kuroshima, 1984). However, the rats in that study had restricted food intake, while the mice in our study had *ad libitum* access to food. Another study using house mice, *Mus domesticus*, found that when mice were given *ad libitum* access to food, individuals that consumed more food were found to be either gaining more mass or losing less mass than mice that consumed less food (Koteja, 2000). Therefore, we can conclude that the absence of a difference in mass between cold- and standard-housed mice in our study was likely due to the *ad libitum* access to food, as this allowed mice to control their food intake and therefore to maintain body mass.

VO$_2$max

VO$_2$max for cold-housed mice was found to be significantly higher than VO$_2$max of mice housed at standard temperatures. These findings are supported by a study using deer mice, *Peromyscus maniculatus*, that found that cold-acclimated mice had an increase in both exercise VO$_2$max and thermogenic VO$_2$max (Hayes, 1986). In many small mammals, brown adipose tissue (BAT) is a primary source of metabolic heat and is a dedicated source of thermogenesis, especially after cold acclimation

(Chappell, 2004). BAT is a highly oxidative tissue, and an increase in BAT and its use should result in an increase in thermogenic VO_2max. If VO_2max is constrained by the overall performance of the pulmonary and cardiovascular systems, any acclimation response that increases VO_2max during one activity, such as thermogenesis, should produce similar increases in VO_2max during other activities, such as exercise (Hayes, 1986). Our findings support that an increase in thermogenesis results in an increase in VO_2max.

Maximum Sprinting Speed

Although we found that VO_2max was significantly higher in cold-housed mice, we found no significant difference in maximum sprint speed between the two housing conditions. This result could be due to our mice not running at their maximal aerobic speeds. Although the mice were prodded along the track, their sprint speed could be seen as voluntary, as the mice controlled their performance largely through their cooperation and not by a moving track. This conjecture is supported by a study using deer mice that found that voluntary running speeds were not constrained by aerobic capacity (Chappell, 2004).

CONCLUSION

Overall, we found no significant difference in mass or maximum sprint speed between mice housed in cold versus standard conditions, but an increase in VO_2max in mice housed at cold temperatures. The changes in VO_2max may be due to changes in muscle and fat composition that may not be reflected in a change in body mass. Body imaging should be used to determine if there is a difference in the ratio of fat to muscle content in mice housed at cold versus standard temperatures. Further studies are necessary to determine the relationship between thermogenic and exercise VO_2max as well as the relationship between VO_2max and maximal aerobic performance.

ACKNOWLEDGEMENTS

WORKS CITED

Brooks, G. A. Fahey, T. D., and White, T. P. 1996. Exercise Physiology: Human Bioenergetics and its Applications. Mayfield Publishers, Mayfield, CA.

Careau, V., and Garland T. Jr. 2012. Performance, personality, and energetics: correlation, causation, and mechanism. *Physiological and Biochemical Zoology*, 85, 543-571.

Chappell, M. A., and Bachman, G. C. 1995. Aerobic performance in Belding's ground squirrels (*Spermophilus beldingi*): variance, ontogeny, and the aerobic capacity model of endothermy. *Physiological Zoology*, 63, 421-442.

Chappell, M. A., Garland, T., Robertson, G. F., and Saltzman, W. 2007. Relationships among running performance, aerobic physiology and organ mass in male Mongolian gerbils. *Journal of Experimental Biology*, 210, 4179-4197.

Chappell, M. A., Garland, T., Rezende, E. L., and Gomes, F. R. 2004. Voluntary running in deer mice: speed, distance, energy costs and temperature effects. *Journal of Experimental Biology*, 207, 3839-3854.

Chappell, M. A., and Hammond, K. A. 2004. Maximal aerobic performance of deer mice in combined cold and exercise challenges. *Journal of Comparative Physiology B*, 174, 41-48.

Hart, JS.1971. Rodents. In: Whittow CG (ed) Comparative Physiology of Thermoregulation. Academic Press, New York, pp. 1–149.

Hayes, J. P., and Chappell, M. A. 1986. Effects of cold acclimation on maximum oxygen consumption during cold exposure and treadmill exercise in deer mice, *Peromyscus maniculatus*. *Physiological Zoology*, 59, 473-481.

Garland T., Jr. 2000. Individual variation and repeatability of maximum cold-induced energy assimilation in house mice. *Acta Theriologica*, 45, 455-470.

Kuroshima, A., and Yahata, T. 1985. Effect of food restriction on cold adaptability of rats. *Canadian Journal of Physiology and Pharmacology*, 63, 68-71.

Paladino, F. V., and King, J. R. 1984. Thermoregulation and oxygen consumption during terrestrial locomotion by white-crowned sparrows *Zonotrichia leucophrys gambelii*. *Physiological Zoology*, 57, 226-236.

Stearns, S. C. 1992. *The Evolution of Life Histories*. Oxford University Press, Oxford.

Wunder, B. A. 1970. Energetics of running activity in Merriam's chipmunk, *Eutamias merriami*. *Comparative Biochemistry and Physiology*, 33, 821-836.

UCR Parking Policy Research

Zining Ji[1], Boris Maciejovsky[2]

[1]Department of Psychology
[2]School of Business Administration

ABSTRACT

In this report, I researched the current parking policy in the University of California, Riverside (UCR). I studied UCR's parking policies because they involve every member of UCR, including students, faculty, staff, and even visitors. There are problems in UCR's parking policies that could be improved to serve commuters more efficiently. The major challenges are the conflicts between number of parking spaces and demand for them, the allocation of parking spaces among the groups cited above, and the impact of price and time limitations on parking use. In this report, I referred to other scholars' research, conducted surveys among 30 undergraduate students, and precisely counted the number of cars in Lot 6 from June 2nd to June 14th, 2014. The results of my study led to recommendations on the efficient use of empty non-reserve spaces and the distribution of undergraduate students' carpool permits. Specially, I recommended giving gold and night permit holders early access to red and blue non-reserved spaces, transforming vacant red and blue non-reserved spots into temporary pay-by-space spots, and assigning undergraduate students daily carpool permits.

Keywords: Parking, Parking Policy, UCR, Allocation, Challenges, Recommendations

FACULTY MENTOR

Boris Maciejovsky

School of Business Administration

Boris Maciejovsky, Assistant Professor of Management and A. Gary Anderson Distinguished Faculty Scholar, received his Ph.D. in marketing from the Sloan School of Management at the Massachusetts Institute of Technology (MIT) and his doctoral degree in psychology from the University of Vienna. His research interests are in the area of decision-making in economic, social, and organizational contexts. He is particularly interested in developing novel laboratory paradigms that help to isolate important aspects of real-world phenomena in order to study how such features influence decisions, processes, and outcomes.

AUTHOR

Zining Ji

Department of Psychology

Zining Ji is a fourth year undergraduate student majoring in Psychology and minoring in Business Administration. Her research focuses on current parking policies in the University of California, Riverside (UCR). She conducted the research with her faculty mentor— Dr. Maciejovsky from the School of Business Administration (SoBA). She is graduating in summer 2015, and her future plan is to continue her education in graduate school.

INTRODUCTION

Parking has become an international issue that impacts most people's daily lives. Parking policies and parking allocation influence means of transportation, traffic, commercial prosperity, and the environment. Due to further urbanization, discussion of efficient parking allocation has increased over the decades. It is even more challenging to "find the best locations for multiple parking lots to serve multiple facilities in a small geographical area" (Klassen et al., 2002). In the context of universities, each parking facility has to serve multiple buildings in a limited geographical area. And in most universities, since the campuses were planned decades ago, adding additional parking spaces is even more difficult.

Since living in a dormitory is not mandatory, most of UCR's students are commuters. In Fall 2013, there were 21,298 students enrolled at UCR, 18,621 of which were undergraduate students (UCR Facts, 2014). However, by April 18th, 2014, the total number of parking spaces was approximately 5,283. The conflict between supply and demand is very sharp. Students often complain that it is hard for them to find a parking spot during peak hours, and they often have to walk a very long distance from the parking lots to their destinations.

Theoretical Background

According to Polacek and Graham, convenience and safety are the primary reasons that students drive to school. They believe that "college campuses impact the communities in which they reside through ebb and flow of students and changing patterns of traffic and congestion (2011)." Goyal and Gomes consider that the optimal solution for parking allocation is to minimize the walking distance for all permit holders (1984). Besides that, the performance of a parking system is also measured by the time that users take to find parking spaces (Kaspi, et al., 2014). Simićević et al. have shown that changes in parking policies influence "the parking type, parking location, transportation mode, car occupancy, destination, travel frequency, travel time, and route (2013)." In particular, parking prices affect car usage, and time limitations determine the type of parking used. A change in parking fees will also result in a relocation effect: an increase in parking fees redistributes congestion away from the core to the periphery (Gillen, 1978). For parking in universities, the problem gets even more complicated because

of a sharper conflict between demand and supply. University parking's demand has a probabilistic nature: every student has his/her unique schedule, and every student's schedule is changing day by day and semester by semester (Batabyal and Nijkamp, 2008). Students' attendance even changes throughout any given term (Klassen et al., 2002). On the other hand, the supply lacks elasticity: buildings on campus were planned decades ago, so it is often impossible to build new parking facilities where they are needed most.

Current Parking Policy

At present, UCR is running a permit-based parking system. The Transportation and Parking Services (TPS) estimates permit holders' probability to park, and then calculates an over-sale ratio, selling more permits than actual parking spaces to maximize the efficiency of parking lot utilization. In general, there are three kinds of permits: red, blue, and gold. The red permit and blue permit are lot specific and can only be purchased by faculty, staff, and graduate students. Gold permits are open to everyone on campus, including undergraduate students. The red permit is the most expensive permit, costing $56 per month. The blue permit sells for $40 per month. The gold permit is the least expensive option, costing $99 per quarter. The red permit has the top priority in accessing parking spaces because every parking lot is red-accessible and some lots are red permit only. Red permit holders are allowed to park in other non-reserved spaces for up to four hours. Blue permit holders can park in most of the parking lots on campus, and are able to park in other non-reserved spaces for up to two hours. Gold permit holders can park in Lots 26, 30, or 50, and are only allowed access to other non-reserved spots after 4 pm (Transportation and Parking Services [TPS], 2014).

According to my interview with Mr. Greg Artman, the director of TPS, there are two general principles for allocating parking permits. The first principle is to protect the rights of permit holders and ensure permit holders' accessibility to campus. Faculty and staff are given priority to parking spaces, because they have relatively more fixed schedules. Many of the parking lots have red-reserved spaces, which are reserved 24/7 for the lot's red permit holders. The TPS wants to ensure the accessibility of red permit holders in each lot. Second, distance to campus and price are positively related. People who are willing to pay more get closer parking spaces. As the least

expensive option, gold permit lots are located at the periphery of the campus.

Survey and Field Research

I conducted a survey targeting UCR undergraduate student's transportation and parking behavior. The survey asked participants' status at UCR, permit purchased, pay-by-space usage, carpool usage, and alternative transportation preference. In total, 30 undergraduate students of various academic years and majors participated in the survey. According to my research, 66.7% of the participants use pay-by-space more than once a week, and 30% of them use pay-by-space more than four times a week. 46.7% of the participants use pay-by-space because the distances between their permits' lots to their destinations are too far. 50% of the participants use carpool more than once a week, and 26.7% of the participants use carpool two to four times a week. 50% of the participants use no alternative options other than driving (see Appendix 1).

In order to analyze how efficiently parking spaces are utilized in Lot 6, I counted the number of cars at 3 and 4 pm from June 2nd (Monday) to June 6th (Friday), 2014 (see Appendix 2). I chose Lot 6 because it involves red, blue, gold permit parking, as well as visitor parking. And I chose 3 and 4 pm because at present gold permit holders can park at Lot 6 only after 4 pm. I separated Lot 6 into three parts: A, B, and C. Section A is red permit only during 7 am to 10 pm, Monday to Friday. Blue, gold, and night permit holders can park in non-reserved spaces in section A after 4 pm, Monday to Friday, and all day on weekends. For section B, red permit holders and blue permit holders can park from 7 am to 10 pm, Monday to Friday. Gold permit holders can park in non-reserved spaces in section B Monday to Friday after 4 pm and all day on weekends. Section C is pay-by-space only, and the rate is $1 for every 30 minutes (two hours maximum) or $8 to park until 10 pm.

The daily change rate of non-reserved spaces in section A and B ranged from 2.3% to 7.5%, and the average change rate was approximately 5.6%. Thus, the number of cars remained relatively steady between 3 and 4 pm (see Appendix 2).

Challenges

At present, UCR's parking allocation faces four major challenges. First, demand for parking spaces continues to increase, resulting from the steady rise in the number of students

enrolled. In the academic year of 2013-14, the total number of students was 20,497 (Strategic Academic Research Analysis [SARA], 2012-14). Parking spaces are extremely short for this year because of the multiple ongoing construction projects. At present, the Student Recreation Center is expanding, leading to the temporary close of Lot 25. And the construction of the Glen Mor campus residence hall occupies the rear part of Lot 13.

Second, the allocation between faculty and staff parking and student parking is inadequate. The number of students enrolled has been increasing these years. However, the number of faculty and staff employed has been decreasing. From 2011 to 2013, full-time employment decreased from 4,375.80 to 4,073.57 (SARA, 2012-14). Faculty and staff are given access to red and blue permits, while undergraduate students can only choose gold permits. According to my survey on undergraduate students' transportation and parking behaviors, approximately 40% of the participants do not have a parking permit. Participants claimed that it is not worth spending $99 per quarter on gold permits. Blue permits only cost $21 more per quarter, and red permits cost $69 more, but these are restricted to faculty, staff, and graduate students. All gold permit lots are open to red and blue permit holders, but red and blue lots are only open to gold permit holders after 4 pm. Gold permit lots—Lot 26, 30, and 50—are located at the periphery of the campus, so undergraduate students often have to walk very long distances to their destinations.

Third, the impact of price discrimination is not adequately utilized. Price differences among red, blue and gold permit are minor. Red permit costs $56 per month, blue permit costs $40 per month, and gold permit costs $37 per month. Moreover, for undergraduate students, there is no effect of price discrimination. Their only option is the gold permit, so their means of transportation are barely affected by the parking prices.

Fourth, the impact of time limitation is not adequately utilized. Except for the pay-by-space areas, time limitations are barely monitored. I interviewed the front desk officer of TPS—Ms. Latasha Rowley. She informed me that parking enforcement officers patrol around parking lots and chalk the tires of cars that have permits from other lots to record their parking time. However, considering the total number of non-reserved spaces, it is hard for the officers to precisely monitor every car's parking time.

Table 3. Lot Capacity and Utilization							
Red		Blue		Gold			
Average Empty Spaces	Capacity	Average Empty Spaces	Capacity	Average Empty Spaces		Capacity	
214.62	718.31	399.21	1740.9	AM	468.82	2695.14	
				PM	144.96	2695.14	
				Total	306.89	2695.14	

DISCUSSION AND RECOMMENDATIONS

At present, the allocation of parking spaces among red, blue, and gold permits is unequal. During my interview with Mr. Artman, he shared some data from the office's "Lot Capacity and Utilization" report with me. The total average empty spaces for red permit are 214.62, and red permits' total capacity is 713.81 (personal communication, April 28, 2014). Therefore, the empty space ratio of red permit is approximately 30%. For blue permit, the ratio is approximately 23%. However, for gold permit, the number is 11.4% (see Table

There are sufficient parking spaces for staff, faculty and graduate students, but not for undergraduate students. For red and blue permit holders, when they are unable to find a parking spot in their lots, they can park in the gold permit lots. However, gold permit holders, or undergraduate students, cannot park in red or blue spots, even if there are plenty of empty spaces in these lots. One recommendation for this problem is to utilize the empty spaces in red and blue permit lots more efficiently.

The empty spaces in red and blue lots can serve as alternative pay-by-space areas for undergraduate students. From 10 am to 4 pm, when most of the faculty and staff have already taken their parking spaces, undergraduate students can park in the alternative pay-by-space. These spaces are charged at the same rate as the ordinary pay-by-space, and the time limitation is also two hours. The alternative pay-by-space spots are free to red and blue permit holders. They can use them just as they use other non-reserved spaces. The alternative pay-by-space areas can also solve the problem that gold permit lots are too far from campus. For example, a student who parks in Lot 30 and wants to go to the Chemical Science building has to walk all the way through the campus (approximately one mile walk). In my survey questionnaire, I asked that

"Why do you use pay-by-space?" 46.7% of the participants answered that they use pay-by-space because "the distance from my permit's parking lot to my classroom is too far."

Currently, carpool permits are only available to faculty, staff and graduate students. According to my survey, 50% of the participants use carpool more than one time per week. 13.3% use carpool once per week, 26.7% use carpool 2-4 times per week, and 10% use carpool five or more times per week. When assigning the carpool permits, TPS will check the applicant's registered addresses. However, for undergraduate students, the office requires matches in both home addresses and class schedules. Students have different preferences for staying on campus. A student might stay in the library for the whole day even he/she does not have class on that day. Assigning the parking permit for longer terms increases permit holders' chances of disobeying the rules. During my interview with the Mr. Artman, he indicated that TPS was afraid that assigning daily carpool permits to undergraduate students might be risky because some of them might simply ask their friends to sit in the car and accompany them to drive through the kiosk in order to get the carpool permit. In my opinion, drivers will not make such great an effort to get a daily carpool permit, if the incentives are not that strong.

Daily carpool permits should be free for gold permit holders, and drivers get the priority of parking in designated carpool areas. For night permit holders or non-permit drivers, daily carpool permits are sold at a discounted price compared to daily gold permits. The daily carpool permit encourages students to share rides, and also monitors carpool more effectively. In addition, gold and night permit holders should be allowed early access to non-reserved spaces in red and blue lots. I counted the number of cars in Lot 6 at 3 and 4 pm from June 2nd to June 6th, 2014. The average

number of non-reserved red spaces was 33.8 at 3 pm, and 40.8 at 4 pm. The number of non-reserved blue spots was 257.8 both at 3 and 4 pm. The average rate of change for red non-reserved spaces was 20.7%. For blue, the rate was 0%. The average rate of change for the total number of non-reserved spaces, both red and blue, was 2.4% (see Appendix 2). The data shows that the number of cars in non-reserved spaces only changes a little between 3 and 4 pm. Therefore, it is reasonable to allow gold and night permit holders one-hour early access to the non-reserved spaces.

REFERENCES

Batabyal, A. A., Nijkamp, P. (2010). A Probabilistic Analysis of Two University Parking Issues. *Ann Reg Sci, 44*, 111-120.

Gillen, D. W. (1978). Parking Policy, Parking Location Decisions and the Distribution of Congestion. *Transportation, 7*, 69-85.

Goyal, S. K., Gomes, L. F. A. M. (1984). A Model for Allocating Car Parking Spaces in Universities. *Transportation Researches Part B, 18B(3)*, 267-269.

Kaspi, M., Raviv, T., & Tzur, M. (2014). Parking Reservation Policies in One-way Vehicle Sharing Systems. *Transportation Researches Part B, 62*, 35-50.

Klassen, K. J., Kumar, A., & Trybus, E. K. (October 2002). Parking Needs Analysis for Multiple Facilities using Multiple Lots. *The Service Industries Journal, 22(4)*, 73-92.

Polacek, G. N. L. J., Graham, C. S. (2011). Parking and Traffic at a Local University. *Journal of Environmental Systems, 33(1)*, 57-69.

Simićević, J., Vukanović S., & Milosavljević N. (2013). The Effect of Parking Charges and Time Limit to Car Usage and Parking Behaviour. *Transport Policy, 30*, 125-131.

Strategic Academic Research Analysis.(2014). Number of Students by College and Student Level 2013-14 Three Quarter Average. University of California, Riverside.

Strategic Academic Research Analysis.(2013). Number of Students by College and Student Level 2012-13 Three Quarter Average. University of California, Riverside.

Strategic Academic Research Analysis.(2012). Number of Students by College and Student Level 2011-12 Three Quarter Average. University of California, Riverside.

Strategic Academic Research Analysis.(2014). Faculty & Staff FTE & Unduplicated Headcounts October 2013 Payroll (excluding Student Employees). University of California, Riverside.

Strategic Academic Research Analysis.(2013). Faculty & Staff FTE & Unduplicated Headcounts October 2012 Payroll (excluding Student Employees). University of California, Riverside.

Strategic Academic Research Analysis.(2012). Faculty & Staff FTE & Unduplicated Headcounts October 2011 Payroll (excluding Student Employees). University of California, Riverside.

Transportation and Parking Services, University of California, Riverside. (2014).   Permit Types: Gold Commuter. Retrieved from http://parking.ucr.edu/permits/undergrad.html

Transportation and Parking Services, University of California, Riverside. (2014). Permit Types: Red Commuter. Retrieved from http://parking.ucr.edu/permits/faculty_staff.html

Transportation and Parking Services, University of California, Riverside. (2014). Permit Types: Blue Commuter. Retrieved from http://parking.ucr.edu/permits/faculty_staff.html

University of California, Riverside. (2014). *About UCR: Facts*. Retrieved June 16, 2014, Retrieved from http://www.ucr.edu/about/facts.html
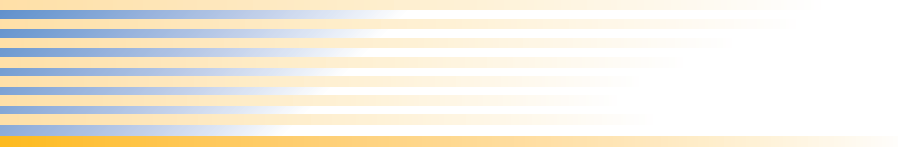
Regulation of Complement Activation Through Factor D Inhibition: A Drug Discovery Study

Sanychen Muk, Ronald D. Gorham, Jr., Dimitrios Morikis

Department of Bioengineering

ABSTRACT

The complement system is our first line of defense against invading foreign pathogens. It is composed of three pathways that act as an immune surveillance, and once activated, work in conjunction with antibodies to eliminate pathogens and maintain homeostasis. The complement protein factor D is responsible for the first enzymatic reaction within the so-called alternative pathway that produces a protein complex called convertase. This sets in motion a robust amplification of complement activation leading to pathogen elimination. Under homeostasis, tight regulation of the complement system is in place, thus protecting host cells from inappropriate complement attacks. Dysfunction in the delicate balance between complement activation and regulation leads to autoimmune diseases such as systemic lupus erythematosus and age related macular degeneration. Therefore, targeted inhibition of complement activation may be a promising therapeutic strategy for many autoimmune diseases. The objective of our study was to identify small (< 500 D molecular mass), drug-like molecules that are capable to bind to factor D and inhibit its function in generating the convertase complex that sustains the amplification reactions. We used a high-throughput virtual screening protocol, based on conformational sampling of both factor D and small molecules, pharmacophore modeling, and protein-ligand docking. We screened all approved and commercially available drugs worldwide (2,924 molecules with 21,320 conformers) and identified molecules with predicted binding affinities for factor D. The computationally predicted factor D ligands will be experimentally tested for binding and inhibitory activity in future studies.

Keywords: complement system, factor D, drug discovery, computational modeling, pharmacophore model, virtual screening, protein-ligand docking.

AUTHOR

Sanychen Muk

Department of Bioengineering

Sanychen Muk is a fourth year student majoring in Bioengineering. He joined Dr. Morikis' BioMoDeL lab in his third year. Sanychen's research is focused on using computational methods for drug discovery. He worked closely with Dr. Ronald D. Gorham Jr. on developing a method to locate small molecule inhibitors for the immune system protein factor D. In the future, he plans to pursue a career in the Bioengineering field, and then return to his education.

FACULTY MENTOR

Dimitrios Morikis

Department of Bioengineering

Professor Morikis' work focuses on immune system function and regulation, structure-dynamics-activity/function relations, design of peptides and proteins with tailored properties, drug discovery, and development of structural and translational bioinformatics methods. His research is predominantly computational, with emphasis on molecular dynamics simulations, electrostatic calculations, free energy calculations, pharmacophore modeling, virtual screening, and protein-ligand docking, and has an experimental component, with emphasis on binding and biochemical assays and NMR spectroscopy.

INTRODUCTION

The complement system is part of our innate immune system, and comprises more than 30 proteins in plasma and on cell surfaces[1-3]. Complement activation proceeds following three pathways known as classical, alternative, and lectin pathways. Dysregulation of the complement system, specifically over-activation, results in excessive inflammation caused by influx and activation of inflammatory cells[3] that leads to tissue damage[4], and is implicated in many autoimmune diseases, such as multiple sclerosis and rheumatoid arthritis[5]. The alternative pathway accounts for most of complement activity, due to the amplification loop that creates C3b rapidly. Thus controlling the activation of the alternative pathway will in turn aid in regulating the entire complement system.
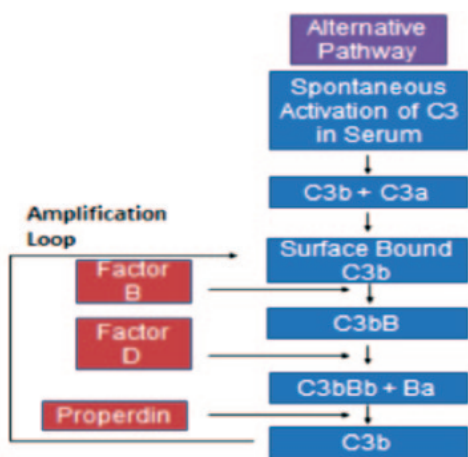
Figure 1. *A simple model of the alternative pathway and its amplification loop. The alternative pathway accounts for about 80% of complement activity. C3bBb is the active convertase complex, after cleavage of Factor B to Bb and Ba by Factor D. Properdin is a positive regulator of the complement system that stabilizes the convertase complex*

The alternative pathway initiates with the tick-over of C3 to C3(H$_2$O) by spontaneous hydrolysis of an internal thioester bond. Tick-over or spontaneous activation of C3 occurs at 1% of total C3 per hour. It produces an altered C3, C3(H$_2$O)[5]. C3(H$_2$O) produces a fluid convertase (C3(H$_2$O) Bb, that cleaves C3, producing C3b. C3b then binds to a foreign cell surface. Next factor B comes in and associates to the C3b bound to a cell surface. Binding to C3b causes a conformational change in its structure. The "locked" scissile bond Arg^{234}-Lys^{235} on factor B is made vulnerable

to cleavage by factor D, due to association with C3b[6,7]. Factor D is a highly specific serine protease that cleaves the Arg^{234}-Lys^{235} peptide bond on the C3bB complex. Cleaving C3bB produces C3bBb convertase. C3bBb convertase is an important enzyme that cleaves C3 to produce more C3b through a feedback mechanism, therefore propagating the amplification of the alternative pathway. Properdin binds to C3bBb to increase its half-life. This ensures that C3bBb convertase is around long enough to cleave C3 (Figure 1).

Regulation is important in ensuring that complement is not activated on host cells. Should there be over-activation, regulation can be supplemented through molecular inhibitors. Many recent efforts have focused on developing complement inhibitors for therapeutic purposes. While many inhibitors have been developed, only one is currently on the market (eculizumab). Several others are in preclinical or clinical development, but most are biopharmaceuticals, which are costly and suffer low bioavailability and in vivo stability. Thus, it is of interest to identify small drug-like molecules that can inhibit complement. Enzymes such as factor D can be inhibited to regulate the activation of the alternative pathway. This occurs by inhibiting cleavage of C3bB, a key complex for the propagation of the alternative pathway, by factor D. The end-result is inhibition of immunologically active proteins or protein complexes, such as C3b and membranes attack complex (MAC), which lead to phagocytosis, and cell lysis, respectively.

In this study, we used a multifaceted approach to identify potential inhibitors of factor D. We studied the interaction between factor D and its native substrate factor B, through analysis of crystallographic structures and molecular dynamics simulations. Many groups have attempted to develop small molecules that inhibit factor D. Since factor D is a serine protease, many of these inhibitors lake specificity, and therefore cannot be used as complement-specific therapeutics. The work described here introduces a novel approach to identify molecules with specificity for factor D compared to other serine proteases. We generated pharmacophore models to aid in the identification of molecules with similar geometric arrangements and physiochemical characteristics to the scissile loop of factor B and its interaction with the factor D active site and

surroundings. We have found potential inhibitors of factor D through virtual screening of the drug-like purchasable subset of the ZINC database [8], using our pharmacophore models, and subsequent docking on factor D, which can subsequently be experimentally tested for complement inhibition.

METHODS

Our method for identifying potential inhibitors of the complement factor D is based on the use of a flexible structural template. To accomplish this, a molecular dynamics (MD) trajectory was used. Molecular dynamics simulates atomic motions by solving Newton's equations of motion under the influence of the protein's own force field. Molecular dynamics simulations are used to detect local and global protein fluctuations and motions that may be functionally important. A 20 ns MD trajectory of the factor D – factor B complex was used as a flexible structural template to delineate the importance of inter-molecular interactions in the formation of the factor D-factor B complex. The MD trajectory was based on the crystallographic structure of C3b – factor B – factor D complex[7] (2XWB), in which we modeled the missing scissile loop (residues 223-240). Only factor B and factor D were included in the simulation; C3b was excluded for simulation efficiency, since we were interested in the interface between factor B and D only. Factor B residues within 12 angstroms of C3b (in the crystallographic structure) were restrained to their crystallographic positions, so as to preserve the native conformation of the C3b – factor B interface. From the MD trajectory occupancy plots for hydrogen bonds, salt bridges, and aliphatic interactions were generated to indicate the percent persistence of these molecular contacts throughout the 2,000 MD snapshots. Residues of the factor B scissile loop that had molecular contacts greater than 60% were selected for development of pharmacophore models. Chemical groups of 15 factor B residues were selected based on the type of contact as important geometric and physicochemical contacts (pharmacophore features) with the active site region of factor D. Physicochemical properties used to define the pharmacophore models included positive charge, hydrogen bond donor, hydrogen bond acceptor, and hydrophobic (Figure 2).
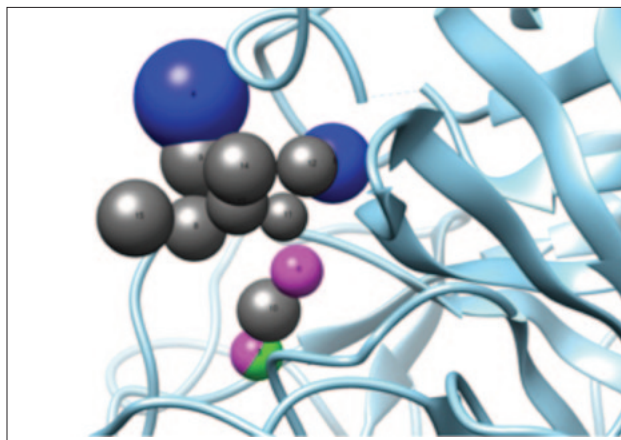
Results of Screening	Color	Feature
5895 ZINC ID	Grey	Hydrophobic
1090 Unique ZINC ID	Blue	Positive
	Magenta	H Acceptor
	Green	H Donor

Figure 2. *The pharmacophore model that we used included fifteen structures with varying features described in the table below the figure. Screening of the pharmacophore model, by a selection of different combinations of the features through the ZINC special Zdd database resulted in 5,895 ZINC ID's and 1,090 unique ZINC ID's. Molecular graphics were generated with Chimera.*

Analysis and selection of pharmacophore features, was done through the program UCSF-Chimera[9] and in-house interaction analysis scripts in R. From the 15 total features, we generated all possible combinations resulting in four, five, or six total features. Using combinations of features we generated 604, 480, and 112 pharmacophore models with four, five, and six, respectively, features.

The web server ZincPharmer (http://zincpharmer.csb.pitt.edu/)[10] was used as a screen engine to search the ZINC database of molecules, against our pharmacophore models. The Zdd special subset of ZINC was used, which contained about 2,924 molecules and 21,320 conformers. The Zdd subset consists of all approved and commercially available drugs worldwide. Selection of total number of pharmacophore features in each screened model was based on specificity; use of fewer than four features would result

in too many (less specific) hits (screened molecules), while a screening of more than six features resulted in stringent model specifications and no hits[11]. We performed filtering, and acquired unique ZINC ID numbers by getting rid of duplicates, using a custom R[12] script, to narrow down the total number of hits, which were used subsequently for protein-ligand docking. In preparation for protein-ligand docking we converted the standard data format (sdf) file containing ZINC models, to the Protein databank file format (pdb) with charges added and torsion angles selected (pdbqt). Target factor D proteins for ligand binding were prepared by converting pdb to pdbqt format in a similar fashion, using Open Babel[13]. Twelve crystallographic structures of factor D from the Protein Data Bank were used to dock the ligands, representing distinct conformations of the target protein. The PDB codes of these protein structures are: 1BIO, 1DST, 1DSU, 1DFP, 1DIC, 1FDP, 1HFD, 2XW9, 2XWA, 2XWB, 4CBN, 4CBO, and 4D9R. During docking the ligands are flexible, while each target protein remains rigid. To account for factor D flexibility, the 12 crystallographic structures were superimposed. The docking site was selected using AutoDock Vina[14]. Area of docking was set to a cube of 2.8 nm across all dimensions surrounding the factor D active site. A computer server with multiple cores was used to perform the calculation of binding energies and docking of the ligand to its target protein. Binding energies (from AutoDock Vina) were used for ranking the docked protein-ligand poses.

RESULTS AND DISCUSSION

Despite this functional difference of factor D, the structure of the active site of all proteases is very similar, comprising of the catalytic triad Ser[195], His[57], and Asp[102][15]. This similarity makes drug discovery against factor D challenging, if potential drugs indiscriminately inhibit all serine proteins in our bodies (trypsin, and chymotrypsin) and their beneficial effects in digestion, immune response, coagulation, and reproduction. Past studies describe unsuccessful drug discovery efforts targeting the catalytic triad[16]. The function of factor D is mediated by the nucleophilic catalytic serine, Ser[195], during a series of reactions that involve proton sharing and transfer between Ser[195], the substrate (scissile loop of factor B), and the catalytic histidine, His[57], which is stabilized by the

catalytic aspartic acid, Asp[102][17]. In addition to the active site, where catalysis takes place, the adjacent specificity pocket and oxyanion hole are also involved in the binding of the substrate and catalysis. Our work differs from earlier efforts in that our search incorporated detailed atomic and dynamic information of the enzyme-substrate complex, allowing for identification of molecules that mimic the native substrate (factor B).

Analysis of our factor D – factor B scissile loop through Chimera resulted in a selection of four chemical group properties to describe the features of the pharmacophore models. Using predicted atomic displacements over time from the MD trajectory, we found the atomic positions of the center of mass of those features at each snapshot. The coordinates were averaged to determine the center point of the pharmacophore feature. Radii of the spheres were set to incorporate 95% of all positions of the group of atoms in the feature from throughout the MD trajectory. We identified 5,895 distinct conformers from pharmacophore screening, yielding a total of 1,090 distinct molecules for docking studies, docking of the 1,090 ligands to the target proteins
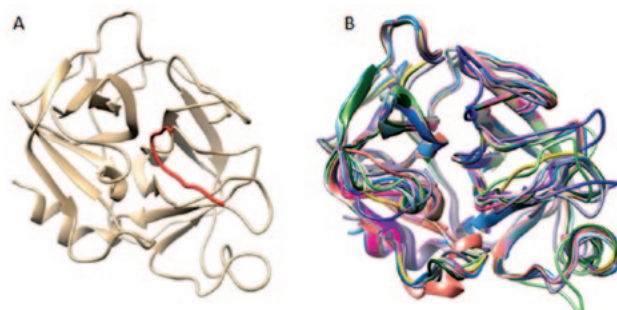
Figure 3. Factor D interfaces with factor B residues 230-239, depicted in A colored red. The superimposed structures in B are showing the flexibility of factor D structure in serum. Molecular superposition and graphics were generated with Chimera.

resulted in 14,170 protein-ligand binding combinations (1,090 molecules times 13 structures, including the original factor D – factor B scissile loop complex and the 12 crystal structures mentioned in Methods). Counting the number of poses each bound ligand could take results in 260,905 docked poses of the ligand to the target proteins (14,170 times up to 20 conformers, some molecules had less than 20 conformers). Superpositioning 12 crystal structures of factor D to the original factor D – factor B scissile loop complex resulted in a root mean square deviation value
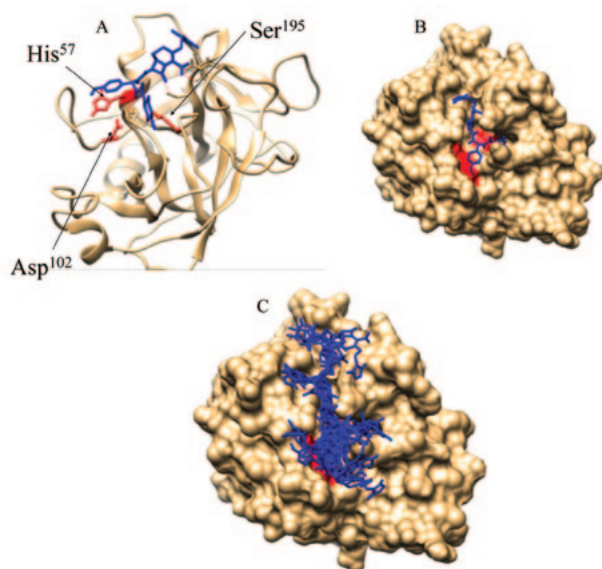
Figure 4. Molecule 1 depicted as blue shown in A interacts with the ribbon structure of factor D (PDB code 1BIO). Molecule 1 has hydrogen bond interactions with residues in the binding site, but none with the catalytic residues shown in red. Shown in B is the surface of 1BIO with molecule 1 bound to the active site; molecule 1 fits nicely into the grooves of the protein surface. Different docked poses of molecule 1 are displayed in C, showing the many positions/orientation that it could assume within the active site. Molecular graphics were generated with Chimera.

(RMSD) of less than 1 Å (Figure 3). Therefore the proteins were similar in structure with slight variations between them; this would accurately represent the flexibility of factor D in binding. During docking we calculated the binding energies between the ligand and target protein to rank the ligands and select a subset of ligands with most favorable binding energies (a process called filtering). A lower (more negative) binding energy indicates a more favorable interaction between the ligand and its target protein. The binding energies ranged between -10.1 and -1.2 kcal/mol. We selected the top 200 poses, totaling 75 molecules, containing the lowest binding energies ranging from -10.1, to -8.6 kcal/mol for further analysis. Molecule 1, shown in Figure 4A, displays a representative ligand that could potentially be used in experimentation. The ligand has a docking energy of -8.7 kcal/mol, therefore it had good affinity to the target protein factor D.

Although binding energy is a good indicator of affinity to a target protein, the interactions occurring at the binding site must also be inspected. Our ligand had to show fitting into the target protein surface. Sometimes molecules may have decently low binding energies, but they would be superficially docked to the surface of the protein, meaning the ligand just lies upon the area of docking without interacting much with the grooves and crevices of the protein surface. In Figure 4B the molecule can be seen fitting into the grooves of the target protein. Figure 4C shows several binding poses of Molecule 1 on factor D, and it can be seen that binding occurs in a distinct binding site and is not randomly distributed onto the protein surface.

Another key factor to analyze is interaction of the ligand to the catalytic site of the target protein. In our case we are looking for ligands that have no direct interaction with the catalytic site residues Asp^{102}, His^{57}, and $Ser^{195[7]}$. Molecules that interact with the catalytic site of factor D were found in previous studies to be undesirable because they also participate in binding and inhibition of other serine proteases, which are not targeted for inhibition. In consequence those ligands that interact with the catalytic triad would not have specificity to just factor D, they would interact with the other serine protease as well. Shown in Figure 4A, Molecule 1 had no interactions with the atoms of the catalytic triad, while still interacting with the active site of factor D through hydrogen bonds, making it a potential steric inhibitor and a suitable candidate for experimental binding studies. We selected the factor D – factor B scissile loop complex for our structure-based drug discovery in order to focus on the physicochemical characteristics that mediate factor B specificity in binding, prior to catalysis.

CONCLUSIONS AND PERSPECTIVE

Through the process of analysis of a molecular dynamics trajectory, pharmacophore modeling, drug database screening, and docking, we were able to identify potential small molecule ligands of factor D. These ligands are small molecules of less than 500 Da molecular weight, with drug-like properties. We have demonstrated that our computational protocol can predict potential factor D ligands; however, ultimate validation will take place after performing experimental binding studies. Additional *in vitro* studies using inhibition or functional assays will be needed to identify potential inhibitors. Inhibition specificity to factor D, compared to other serine proteases,

will need to be studied in order to develop lead factor D inhibitors. Additional absorption distribution, metabolism, excretion, and toxicity (ADMET) studies in pre-clinical animal models will be needed to develop lead molecules to therapeutic candidates. In addition to docking the ligands to factor D structures we also intend to perform docking with other serine protease structures, as a first step towards studying specificity. Our high-throughput computational protocol can accelerate drug discovery by guiding and complementing experimental research.

ACKNOWLEDGMENTS

REFERENCES

Janeway CA Jr, Travers P, Walport M, et al. Immunobiology: The Immune System in Health and Disease. 5th edition. New York: Garland Science; 2001. The complement system and innate immunity.Available from: http://www.ncbi.nlm.nih.gov/books/NBK27100/.

Morikis D, and Lambris, JD (Eds.) (2005) *Structural Biology of the Complement System*, CRC Press/Taylor & Francis Group, ISBN 0-8247-2540-9.

Walport MJ. "Complement. First of Two Parts." *The New England Journal of Medicine* 344, no. 14 (April 5, 2001): 1058–66. doi:10.1056/NEJM200104053441406.

Walport MJ. "Complement. Second of Two Parts." *The New England Journal of Medicine* 344, no. 15 (April 12, 2001): 1140–44. doi:10.1056/NEJM200104123441506.

Ballanti, E, Carlo P, Elisabetta G, Marta B, Gioia DM., Maria SC, and Roberto P. "Complement and Autoimmunity." *Immunologic Research* 56, no. 2–3 (July 2013): 477–91. doi:10.1007/s12026-013-8422-y.

Thurman JM, and Holers MV. "The Central Role of the Alternative Complement Pathway in Human Disease." *Journal of Immunology (Baltimore, Md.: 1950)* 176, no. 3 (February 1, 2006): 1305–10.

Forneris F, Ricklin D., Wu Jin, Tzekou A, Wallace RS, Lambris JD, and Gros P. "Structures of C3b in Complex with Factors B and D Give Insight into Complement Convertase Formation." *Science* 330, no. 6012 (December 24, 2010): 1816–20. doi:10.1126/science.1195821.

Irwin JJ, and Shoichet BK. "ZINC – A Free Database of Commercially Available Compounds for Virtual Screening." *Journal of Chemical Information and Modeling* 45, no. 1 (2005): 177–82. doi:10.1021/ci049714.

Pettersen EF, Goddard DT, Huang CC, Couch GS, Greenblatt MD, Meng CE, and Ferrin ET. "UCSF Chimera--a Visualization System for Exploratory Research and Analysis." *Journal of Computational Chemistry* 25, no. 13 (October 2004): 1605–12. doi:10.1002/jcc.20084.

Koes DR, and Comacho JC. "ZINCPharmer: Pharmacophore Search of the ZINC Database." *Nucleic Acids Research* 40, no. W1 (July 1, 2012): W409–14. doi:10.1093/nar/gks378.

Gorham RD. "Mechanistic Exploration of Complement System Interactions and Design of Complement-Targeted Therapeutics" PhD dissertation, University California Riverside, 2013.

R Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

The Open Babel Package, version 2.0.0. http://openbabel.sourceforge.net/ (accessed Dec 1, 2005).

Trott O, and Olson AJ. "AutoDock Vina: Improving the Speed and Accuracy of Docking with a New Scoring Function, Efficient Optimization, and Multithreading." *Journal of Computational Chemistry* 31, no. 2 (January 30, 2010): 455–61. doi:10.1002/jcc.21334.

Petsko GA, and Ringe D (2004) Protein Structure and Function, New Science Press, ISBN 0199556849.

Morikis D, and Lambris JD (2002) Structural aspects and design of low-molecular-mass complement inhibitors, *Biochemical Society Transactions30:1026-1036*.

Xu Y, Ponnuraj K, Narayana SVL, and Volanakis JE (2005) Factors D and B: Substrate-Inducible Serine Proteases of the Alternative Pathway of Complement Activation, in *Structural Biology of the Complement System*, Morikis D, and Lambris, JD (Eds.), CRC Press/Taylor & Francis Group, ISBN 0-8247-2540-9.

Assessing Linguistic and Cultural Literacy among Saudi Arabian Students

Clare O'Brien[1], Dany Doueiri[2], Jeffrey Sacks[1]

[1]Department of Comparative Literature & Foreign Languages
[2]Department of World Languages and Literature, California State University - San Bernardino

AUTHOR

Clare O'Brien

Department of Comparative Literature & Foreign Languages

Claire O'Brien is a fourth year Foreign Language major, with a focus in Arabic and German. Her research topic reflects her interest in the social and political implications of the different forms of Arabic throughout the Arab world. As an undergraduate student, she studied abroad in Jordan, worked as an Arabic teaching assistant, attended national conferences for her field of study, acted as a peer mentor, and created lasting relationships with students and faculty alike. She intends to continue Arabic studies in graduate school and hopes to become a professor of Arabic and Middle Eastern Studies at a university in the future.

ABSTRACT

This study examines the linguistic and cultural literacy of Arabic among Saudi Arabian students. This report will discuss the general issue of literacy of Arabic in the Arab world and the various efforts made to eradicate illiteracy. To test students' linguistic and cultural literacy, a survey was distributed to Saudi Arabian international students, who are only temporarily in the United States earning their Bachelor's and Master's degrees. This report will address the results of selected survey questions and speculate about possible factors influencing students' answers, though the study's primary purpose is to demonstrate the presence of the deficiency rather than investigate its actual causes and sources. The results of this study contribute to the discussion of education reform and literacy initiatives in the Arab world, by providing evidence that such reform is necessary.

Keywords: illiteracy, cultural literacy, language preservation, Arabic, Saudi Arabia, education

FACULTY MENTOR

Dr. Dany Doueiri

Department of World Languages and Literature, California State University - San Bernardino

The accomplishments of Dr. Doueiri, Associate Professor and Coordinator of the Arabic Language Program of the California State University, San Bernardino, include many pioneering efforts in the fields of Teaching Arabic as a Foreign Language (TAFL), Arabic language program administration, financial sustainability, language assessment, advocacy, Middle East studies, and more. Dr. Doueiri has also successfully established one of the most rigorous and affordable Arabic language summer residential immersion programs in the U.S. and abroad. He is co-founder and academic director of the Center for the Languages, Arts and Societies of the Silk Road (CLASSRoad), and has offered training workshops and programs for teachers of Arabic on a wide range of topics.

FACULTY MENTOR

Jeffrey Sacks

Department of Comparative Literature & Foreign Languages, University of California, Riverside

Jeffrey Sacks was educated in Cairo, Beirut, Ann Arbor, Austin, and New York, where he earned a Ph.D. at Columbia University at the Institute for Comparative Literature and Society and the Department of Middle East and Asian Languages and Cultures (now the Department of Middle Eastern, South Asian, and African Studies). He works and writes on poetics, literary theory, Arabic studies, the Arabic nineteenth century, Arab Jewish writing, the question of Palestine, Arabic philosophy, colonialism, psychoanalysis, philology, and loss.

1. INTRODUCTION

In 2010, the UNESCO published its "Atlas of the World's Languages in Danger" after alarming reports warned that 50% of the 6,000 languages currently spoken around the world will be extinct by the end of the 21st century.[1] Declines in linguistic proficiency and cultural knowledge result not only in a loss of heritage but could also negatively impact a myriad of critical issues such as promoting diversity, preserving identity, preventing conflicts, and improving socio-economic conditions. While Arabic is not necessarily in danger of being completely eradicated in the near future, some effects of globalization as well as internal apathy may be contributing to the decline of Arabic's usage, perceived practicality, and how it represents national/cultural identity among its native speakers.

2. PURPOSE

The purpose of this study is to examine the linguistic skills and cultural literacy among Saudi Arabian students who are only temporarily in the United States earning their Bachelor's, Master's, or Doctorate degrees. These results may provide evidence for the further development of literacy initiatives and the preservation of linguistic (and therefore cultural) heritage in the Arab world.

Arabic is a diglossic language. The spoken form, any regional dialect, is vastly different from the written form, Modern Standard Arabic (MSA). Linguistic literacy in Arabic is defined as a speaker's proficiency in MSA—the language used in formal, academic, and religious contexts. Without this proficiency, people's ability to analyze historical documents, news media, religious texts, government publications, and academic work (to name but a few) is vastly limited.[2] These texts are sources of cultural history and a means of international dialogue. The inability to understand the language of these texts results in a loss of important knowledge that the sources undeniably provide. This in turn affects the identity of a people, an identity originally founded upon a rich heritage that includes their history, traditions, and language.

Both educators and scholars in the Arab world today agree that the use of MSA is not emphasized enough in education. Consequently, students are graduating school with great deficiencies in Arabic linguistic and cultural knowledge.[3] This study contributes to the current discussion by providing evidence of these deficiencies, which in turn will help shape future education reforms and initiatives throughout the Arab world.

3. BACKGROUND

Because Saudi Arabia falls below international literacy standards,[4] the country has implemented numerous initiatives to improve education standards and adult literacy rates within the kingdom.[5] As a result, Saudi Arabia has raised its literacy rate from 5% in 1956[6] to 87.2% in 2012.[7] In 2003, Saudi Arabia implemented the National Literacy Program that aims to completely eradicate illiteracy, describing literacy as a "right" to all citizens.[7] This program consists of a series of classes specific to people's individual education levels, and especially aims to integrate "isolated" communities by offering financial and employment incentives for those who enroll.[7] The government also employs television, radio, mosques, and community centers[7] to ensure that literacy is accessible and achievable throughout the kingdom. Saudi Arabia has made education universal by establishing a program that extends across the country and uses means other than a formal education system, to ensure that education is not restricted to the urban wealthy. In light of the current globalized community, a largely literate population is able to more effectively represent Saudi Arabia in international dialogue and thus maintain political power.

Although scholarship on reducing illiteracy in Saudi Arabia has focused on adult education,[8] little work has been done on the product of Arabic education in primary and secondary schools. This is a widely recognized issue that has been addressed in multiple conferences involving the Arabian Gulf region as well as other Arab nations.[9] The United Arab Emirates (UAE) has recognized this language deficiency within its own borders and has created numerous initiatives to maintain its cultural identity that is "integrally linked" to the Arabic language.[10] Such initiatives are important in the Arabic Gulf countries in general, where 37% of the entire population in the region was made up of immigrants as of 2004.[11] This large influence of immigrants in the Arabian Gulf has caused people to use English as the primary means of communication,[12] and therefore Arabic has become marginalized within the society and the education system.

The use of MSA among native speakers is impeded by the increasing use of local dialects and adoption of lone words. One researcher Hanif focuses on Arabic media, that as a result of the prominence of "foreign words" and "colloquial terms" in media, "the importance and role of our Arabic language has retreated significantly, in terms of practicality and use."[10] Arabic speakers are therefore not necessarily encouraged

to use the Modern Standard Arabic in one of MSA's most prominent platforms, and are instead relying more upon foreign vocabulary and regional dialects, even in formal settings. Speakers may therefore view their own language as less adaptable and perhaps obsolete in certain scenarios.

Focusing on the substitution of foreign words in particular, the value of MSA as well as Arabic in general is impacted. Suzanna Talhouk, an Arabic language advocate from Lebanon, discusses this as a tragedy. She argues,

> the Arabic language doesn't satisfy today's needs. It's not a language for science, research, a language we're used to in universities, a language we use in the workplace, a language we rely on if we were to perform an advanced research project, and it definitely isn't a language we use at the airport.[13]

Talhouk emphasizes the subordination of Arabic to foreign languages in multiple instances. She asserts that Arabic is now largely confined to informal situations. To communicate formally and/or to an educated audience, many do not rely on their mother tongue but rather a foreign language. This supports Hanif's statement that in these particular situations, Arabic has lost its "practicality." Arabic is not upheld and esteemed in an educational capacity in the same manner as a foreign language,[13] and many students thus believe that Arabic is simply not as useful. The importance of MSA proficiency and speaking Arabic in general has been demoted and can lead to a significant loss in cultural and linguistic identity. Through Arabic education reform, however, such heritage and knowledge can be preserved.

Academics have also debated the idea of cultural literacy. One American university professor issued a cultural literacy quiz to his students, similar to the questionnaire of this study. The results of his experiment were "sobering," as many students could not identify the significance of prominent historical figures, such as Mahatma Gandhi and Henry David Thoreau.[14] Without cultural literacy in the general population, he argues, this "possession of knowledge" will remain among the elite.[14] Without this knowledge, a person is denied access to certain resources and opportunities due to the inability to connect and communicate with others on a more nuanced and academic level.[14] This idea is especially pertinent to the issue of Saudi Arabia. The Saudi Arabian government has, in fact, worked diligently to rectify the problem of both linguistic and cultural illiteracy and

ensure its accessibility to those outside the urban elite. It is important that those outside this privilege are afforded the opportunity, through literary skill as well as knowledge, to be able to change their economic statuses if they choose.

4. METHODOLOGY

An anonymous three-part survey was distributed to 101 students (in seven different American colleges/universities). Of these surveys, 100 were deemed valid for analysis and statistical purposes. Students from both genders, ages 18-37, were surveyed. Most were earning Master's degrees at the time of participation. Part I of the survey assesses cultural competency, Part II assesses written language competency (written MSA), and Part III assesses formal oral competency (spoken MSA[15]). In total, sixteen elementary questions pertaining to Saudi Arabia as well as the Arab region were presented. They comprised of topics related to history, economics, health, Islam, literature, media, international relations, and Arabic language. These questions were based on information provided by the Saudi Arabian Embassy website, as well as learning outcomes of introductory Islamic and Arabic culture and language classes from a local American university. In other words, the facts in this study's survey are so rudimentary that it is taught to students who are just being introduced to the Arabic language, culture, and Islam, let alone a native Arabic speaker and citizen of Saudi Arabia who has graduated from high school. Research was conducted on the topics and sources in order to gauge what is generally considered common knowledge that a Saudi Arabian citizen and native Arabic speaker should know by the time she or he reaches the university level.

5. RESULTS AND DISCUSSION

a. Identity

On the question of identity and national history, 80% of students correctly identified the founder of Saudi Arabia, and one 24-year old male even remarked that it would be "shameful" if a person did not know who founded the country. Students spoke highly of the royal family, describing how it has provided for its citizens free education, medical care, and social welfare, all as stated in the country's Basic Law of Governance. One 26-year old male further expressed that he would not consider living in the United States and intends to return directly to his homeland after completing his studies. He explained that "unlike other Arab countries,

such as Palestine and Syria," Saudi Arabia is not undergoing severe economic hardship or a violent conflict. Based on student comments and survey results, students admire how the royal family of Al Saud has built Saudi Arabia and are therefore loyal to the monarchy and the nation.

This loyalty is not only contingent upon effective social welfare in the kingdom, but also on the government's adherence to Islamic laws and practices. The state has established its legitimacy through the politicization of Islam.[16] The state asserts, "the Islamic religion is the foundation of Saudi culture."[17] To be Saudi, then, inherently means to be Muslim. The Law of Governance also states, "In support of the Book of God [the Quran] and the Sunna of His Messenger [Mohammed] (PBUH),[18] citizens shall give the pledge of allegiance (bay'a) to the King, professing loyalty in times of hardship and ease." In short, by supporting the king, a person is inherently supporting Islam and therefore Saudi Arabia. Answers to the questions about national history, Islam, and Arab relations indicate that how students may identify themselves as Saudi Arabian, Muslim, and Arab is an intricate balance of state and religious doctrine.

Considering this balance of religious and national identity, it is conceivably the government's duty to educate students to be proficient in the language of the nation's official religion, let alone the language of literacy and academia. Assessing students' linguistic literacy is therefore an assessment of how prepared students are to engage in religious practices and discussions, and how much they know of their religion.

b. Literature

Student responses to questions regarding language and literature may reflect the importance of cultural and linguistic literacy as it pertains to employment opportunities. Only about one fifth of participants were able to identify two authors from Saudi Arabia, the rest only being able to identify one author or work, or no author or work at all. Despite the integral role literature has played in both national and Islamic heritage, literature may be less valued by some in contemporary society due to employment conditions and the global economy. One could speculate that it is partially due to the fact that many students in Saudi Arabia focus on studying fields that will be directly applicable in the job market. One 22-year old female opined that in general, Saudi people obtain degrees in order to obtain financially secure jobs that will allow people to live

a comfortable family life, not necessarily because people are especially interested in a certain field. Employment conditions have changed in a way that make studying certain disciplines more important than ever. Until the 1980s, the Saudi Arabian government employed most graduates, "often regardless of the graduates' actual qualifications and capabilities".[19] The government is unable to absorb the increasing number of graduates, and, therefore, skills and qualifications will now be taken more seriously in terms of employment.[14] Students are thus looking to develop skills that are in line with the current state of the economy. The largest three job industries in Saudi Arabia today are general administration, wholesale and retail trade, and construction,[20] none of which emphasize any vast literary or cultural knowledge. It seems that many students are tailoring their education specifically to the type of job they anticipate obtaining and, consequently, literary history and tradition may become less important.

c. Linguistic Proficiency

Responses to the Arabic linguistic proficiency question also imply a stronger motivation to study fields, such as English, that will increase a person's employability versus a similar motivation to study Arabic, the respondents' native language. Students were asked to conjugate the verb "masha" (to walk) with various pronouns. Of the 79 students who answered the language portion, an overwhelming majority, 87%, answered with spelling mistakes. Of these students, 23 of them were also asked to write the correct grammatical structure of two simple sentences. Only half of the students were able to correctly structure the first sentence. (These grammatical concepts are taught before students reach high school.)

All participants in the study are obtaining degrees in the United States in order to learn English. Due to Saudi Arabia's role as the world's largest oil producer and exporter,[21] learning English is becoming increasingly more important. Applicants who know English are thus more competitive for positions in the private sector and foreign markets, employment opportunities that the government is now unable to supply. While three students confirmed that Arabic is still important in Saudi Arabia, both socially and religiously, one student mentioned that even government publications have prevalent spelling mistakes. When asked to elaborate on why they thought this is, the students said they did not know. A review of a book about changing identities among youth in

Saudi Arabia by Mai Yamani summarizes Yamani's findings, saying, "education that will lead to employment prospects involves knowledge of English (symbolically opposed to Arabic)."[22] It is not necessarily that people do not value their native language, but that the value of cultural and linguistic literacy may be currently marginalized in favor of fields that will provide a more stable income.

The challenge of effectively teaching and learning MSA, considering the diglossia of Arabic, may also contribute to students' spelling errors. Written language is not necessarily used in people's daily living other than specific religious instances. Especially when communicating among friends, many times people will spell words as they are said rather than how they are correctly written. Learning the written language is essentially like learning a second language for native Arabic speakers, in that speakers must learn different vocabulary, grammar, and spelling than what they speak. Perhaps, then, teaching the written language to native speakers in school should be treated more like learning a second language rather than treating the written language as if it is intuitive to students.

6. CONCLUSION

The results of this study indicate that the majority of participants show marked deficiencies in foundational linguistic skills and cultural literacy. While further studies must be conducted in order to test the prevalence of this deficiency throughout Saudi Arabia, the study provides evidence that confirm many educators' and scholars' views that these deficiencies exist, and they must therefore be addressed through reform in education policies.

One of these policies is that of the Saudi Arabian Cultural Mission (SACM), which provides Saudi students scholarships to earn higher degrees abroad. SACM prohibits students from taking any cultural or language classes pertaining to Arabic or Islam while studying abroad, though the classes may fulfill general education requirements.[23] SACM asserts that because these students have grown up and been educated in Saudi Arabia, these classes are simply redundant and not challenging.[23]

One Saudi citizen also commented that these students do not need any cultural or linguistic remediation classes, as they "have been speaking Arabic since they were born," in addition to living in an Islamic culture. He asserted that *if* indeed a student requires some sort of remediation, there are schools and universities in Saudi Arabia that can provide a better Arabic education than in the United States. This paper is not analyzing the effectiveness of an Arabic education in the U.S. versus an Arabic speaking country, but rather showing a deficiency in linguistic and cultural knowledge that the Saudi education system should have prevented. The evidence of this research proves that, despite their background, many students do not actually meet all the required learning standards of even these general education Arabic/Islamic culture classes in the U.S.

In light of this study's results, I recommend two education policy changes to promote MSA literacy. High schools in Saudi Arabia should continue a rigorous MSA education,[24] as this is the language that students must use for all future academic, civic, and religious pursuits. Per some students' comments, students' linguistic deficiencies may have resulted from not studying Arabic in high school. Students should also be permitted to take Arabic and Islamic classes while earning their degrees abroad, as scholarships of other Gulf countries allow.[25] Certainly, students should not forgo their intended field study to focus on Arabic in the U.S. Still, students can only benefit from taking these introductory-level classes, while at the same time satisfying university degree requirements. Taking these classes in the U.S. would actually allow students to also practice English in an authentic classroom setting as well as promote cross-cultural understanding, two significant objectives of the Saudi Arabian Cultural Mission. Many, including SACM, assume that students have long-ago mastered the material of these classes. According to this study's results, however, it is clear that students are showing marked deficiencies and can benefit from even introductory-level Arabic language and cultural classes.

Clare O'Brien

Footnotes

1. Moseley, Christopher (ed.). 2010. Atlas of the World's Languages in Danger, 3rd edn. Paris, UNESCO Publishing.

2. Proficiency in formal Arabic is especially important in Islam. The Quran is written in what is considered to be the most eloquent Arabic and is linguistically referred to as the ultimate source of Arabic grammar.

3. Abdulaziz Al-Nasr, Salah. "Students' Deficiency in Arabic: Realizing the Problem and the Delay of Its Treatment." *Al-Riyadh* 20 Apr. 2007. Web. 2015.

4. Mullis, Ina, Michael O. Martin, Pierre Foy, and Kathleen T. Drucker. *PIRLS 2011 International Results in Reading.* Rep. Boston, MA and Amsterdam, the Netherlands: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College and International Association for the Evaluation of Educational Achievement (IEA), 2012.

5. UNESCO, comp. "Literacy and Adult Education in the Arab World." CONFINTEA V Mid-Term Review Conference, Bangkok, September 2003. UNESCO-Beirut, Regional Office for Education in the Arab States and UNESCO Institute for Education, Hamburg, n.d. Web.

6. Vassiliev, Alexei. *The History of Saudi Arabia.* New York: New York UP, 2000. Print.

7. "Saudi Arabia Statistics." UNICEF, 2013. Web. 2015.

8. *The Achieved Progress In the Field of the Eradication of Illiteracy in Kingdom of Saudi Arabia.* Rep. N.p.: Kingdom of Saudi Arabia Ministry of Education, 2008. Web. 2015.

9. AbuBakr, Asmaa Fathi Younis. *Factors Contributing to the Decline of the Arabic Language.* Diss. The British University in Dubai, 2013. Web. 2015.

10. "Nurturing Arabic Will Help Connect to Our Roots." *United Arab Emirates Ministry of Cabinet Affairs.* 24 Apr. 2012. Web. 2015.

11. Kapiszewski, Andrzei. *Arab vs. Asian Migrant Workers in the GCC Countries.* Rep. United Nations, 2006. Web. 2015.

12. Weber, Alan S. "Politics of English in the Arabian Gulf." Proc. of Conference on Foreign Language Teaching and Applied Linguistics, Saravejo. May 2011. Web. 2015.

13. Talhouk, Suzanne. "Don't Kill Your Language." TEDxBeirut 2012. TED. Web. 2015. English translation by Khalid Marbou.

14. Schweizer, Bernard. "Cultural Literacy: Is It Time to Revisit the Debate?" *The NEA Higher Education Journal* (2009): 51-56.

15. There are several variations of MSA. For the purpose of this study, if a student were able to express himself/herself in Educated Arabic, a combination of strict MSA and dialect, the rater would consider the respondent proficient in MSA.

16. Nevo, Joseph. "Religion and National Identity in Saudi Arabia." *Middle Eastern Studies* 34.3 (1998): 34-53. Print.

17. "Saudi Arabia- Kingdom of Humanity." *Ministry of Higher Education.* Kingdom of Saudi Arabia, 4 Aug. 2010. Web.

18. Peace Be Upon Him, a common Islamic expression used when referring to the Prophet Mohammed

19. Prokop, Michaela. "Saudi Arabia: The Politics of Education." *International Affairs* 79.1 (2003): 77-89. Print.

20. "Saudi Arabia: Economic Weakness Led to Unemployment Rate Hike." *Meeting of Labor and Employment Ministers.* International Labor Force, Mar. 2010. Web.

21. Whitaker, Brian. "Saudi Arabia in the Age of Globalization." *Al-Bab.* 2011. Web.

22. Yee, Danny. "Book Review of Changed Identities: The Challenge of the New Generation in Saudi Arabia by Mai Yamani." *Book Reviews by Danny Yee.* 1 Oct. 2002. Web.

23. Osman, Hannan. "SACM policy." Message to Dany Doueiri. 28 February. 2014. Email.

24. Al-Abdulkareem, Saleh. *Education Development in Saudi Arabia.* Rep. King Saud University, n.d. Web.

25. Students on scholarships from the UAE, Oman, and Qatar are not prohibited from taking such classes.

Women and the United States Food Administration

Enid Ocegueda, Jonathan Eacott

Department of History

ABSTRACT

Women were generally assumed to have been accepting of the idea of volunteerism during the First World War. Throughout my paper, I discuss the use of pledges and posters to disintegrate how well mass distribution of visual imagery did in terms of the recruitment for volunteers needed. In addition, the utilization of propaganda geared towards children was methodically used to ignite fear in society, specifically towards women. With the utilization of Special Collections and Archives from UCR Rivera Library, among other sources, I argue just how well founded propaganda methods were used by the United States Food Administration and how well committed they were to aggressively maintaining the patriotic sentiments vital during their involvement in the war. Through this research, it has been well indicated that the systems and techniques that were put into place by the USFA were very successful in distributing the information necessary to maintain women at the forefront for what they believed to be the ideal household soldier.

Keywords: WWI, United States Food Administration (1917-1920), propaganda, household soldiers, home front, home conservation, Hooverizing

FACULTY MENTOR

Jonathan Eacott

Department of History

Jonathan Eacott is an Assistant Professor of History. He has received several research awards for his work on the British and their empire from the eighteenth century to the present. He is the author of Selling Empire: India in the Making of Britain and America, 1600-1830, which uncovers the vital importance of India in the economic, political, and cultural development of the British empire in the Atlantic Ocean and, later, the early American Republic.

AUTHOR

Enid Ocegueda

Department of History

Enid Ocegueda is a third year student majoring in History with a concentration in U.S. History. Her research mainly focuses on the effect propaganda had on women during the First World War. Through the utilization of Special Collections and Archives here at UCR, she was able to commence her research and gain knowledge of the effects of propaganda on society. She plans to pursue graduate study in Public History and/or Library Science once she graduates from UCR next year.

Soon after declaring war, the U.S. government established the United States Food Administration (USFA) in August of 1917 to promote the mobilization of both men and women in implementing food conservation to produce the amount of food needed to aid their allies. As the director of the USFA, Herbert Hoover expressed the need for volunteerism as an alternative to food rationing. It was in their best interest to deprive those who can afford it, rather than depriving those who could not bear the sacrifice[1]. Though both men and women were called upon to perform this task, eighty percent of the country's food passed through the hands of women making them the main target of propaganda[2]. Through the use of different propaganda outlets, the food administration managed to reach women on many new levels. They managed to materialize their propagandistic goals through the utilization of motion pictures, advertising, speakers, educational institutions, and also with the cooperation of churches, patriotic societies, public eating-places, libraries, and retail stores.

Historians have argued that women had given much of their time for this cause on the basis of patriotic sentiments. In her book, *For Home and Country,* Celia Kingsbury recognizes the role propaganda played during the First World War in terms of the manipulation tactics used towards women for the Food Administration's benefit. She touches upon the idea of propaganda as being an emotional experience that induces the mass hysteria among a society at a time of war, further penetrating their ideals. It is maintained that the concept of manipulation of public opinion was key to the idea of propaganda, in ways that idealizes the means in which propaganda was used towards women. As mentioned in her book, political sociologist Harold Lasswell states that propaganda is concerned with "the management of opinions and attitudes by the direct manipulation of social suggestion rather than by altering other conditions in the environment." In other words, propaganda works solely on the repetition of ideas or images to further suggest an idea. Women were not able to escape the war on the home front or the United States Food Administration's aggressive attempt to suck them into their volunteerism. Propaganda was a form in which they would be manipulated into a mass opinion about volunteerism further enticing them to participate. Stephen Ponder, for example, author of "Popular Propaganda: The

Food Administration in World War I," states that Hoover had the intention of appealing to those that he believed directly controlled the nation's food consumption: women. According to Tanfer Emic Tunc, author of *Less Sugar, More Warships: Food as American Propaganda in the First World War*, much of the food-related propaganda was ultimately gendered – both in language and in imagery – which would "appeal to the female sensibility of maternal sacrifice." The Food Administration sought to exploit this characteristic of women along with their patriotic sensibilities. Through my archival research I expand on the notion that propaganda, as used by the USFA, was a massive form of manipulation that shaped public opinion, more specifically to that of women, into volunteerism. The USFA managed to gear women into becoming what many historians called "household soldiers." By and large, through the use of all sorts of propaganda methods, the USFA was able to establish the unification of American women on the home front to volunteer, and thus, ultimately create a patriotic state of mind amongst them, the type of mindset capable of winning the war.

Many tactics, such as pledging, became a way for women to officially integrate themselves as members of the administration, emphasizing their significance to the food conservation operation. It was by means of these pledge campaigns that women were introduced to window, or home cards, which were to be hung on their front windows to show their support, and to show that they were, indeed a member of United States Food Administration (Figure 1)[4]. This type of propaganda method played on patriotic

sensibilities of Americans and therefore initiated a chain of informative techniques to exploit such emotions. The type of information that allowed the United States Food Administration access to every household had to do in many parts with the distribution of information. Again, by exploiting, not only patriotic sensibilities, but also the humanitarian appeals of volunteerism,
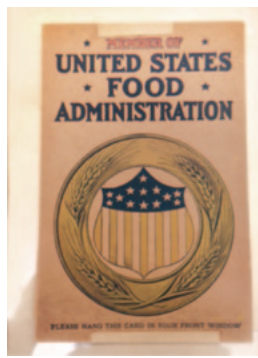
Figure 1. United States Food Administration Home Card. UCR Special Collections and Archives, Collection 030.

pledge cards allowed women to join as actual members. Once women signed their pledge forms, they would receive a pledge card to proudly display on their window and a "home card" that came with instructions for how to conserve which was to be displayed in their kitchen. These cards allowed women to showcase their proud support for the USFA and establish solidarity among women during the war. Not only were they for show, but they also managed to manipulate more and more women into pledging because those around them had pledged. Women were becoming the epitome of self-reliance through this show of faith towards the USFA, just like Hoover and the administration had intended. Even though the sizes in proportion of the pledge cards were not massive, it was rather the immense distribution that permitted the administration to become practically inescapable. Compared to the first pledge campaign, which lacked in funds and distribution methods, the second pledge campaign was aided by 500,000 volunteers that included women's groups, churches, clubs, Boy Scouts, and local politicians. Volunteers went from door to door, canvassing and distributing the information as much as they could. All together, they managed to accumulate 13 million to 14 million households to register with the administration. As mentioned before, propaganda depends on the power of suggestion and the repetition of images.

Despite the fact that many of the pledge cards were intended for women, it did not stop the administration from targeting younger audiences as well. The Food Administration also created pledges for children to sign. This encouraged not only women in the household, but also children to participate in the food conservation efforts, putting a bit more pressure on women to conserve when they had children who were themselves encouraged to pledge. The words utilized in the pledge suggest, again, that patriotism should be above all else.

> In helping my America
> With all my loyal heart
> This is a PROMISE, and I hope
> All children make the same.
> I'll be a good American

This instilled in the American mind, that not volunteering would be a dishonor when even children were pledging. The distribution of this pledge allowed for information

about the Food Administration to seep through, even by ways of utilizing one's own children. Through the propaganda that was directed specifically towards children, the mother-child unit was very much emphasized and roles between boys and girls were even implemented at a young age. While men were off at war and women were helping at the home front, the nuclear family dynamic was still in place, positioning girls as nurses and boys as the soldiers; playtime certainly became gendered. Children were, in fact, encouraged to participate in the war and play war games "in which hating the enemy became great fun."[7]

Figure 2. *"Little Americans Do Your Bit!" Poster by Cushman Parker.*

Not only was propaganda used as a way to integrate children as well as their mothers, it certainly became imperative that children be trained to hate the enemy. Children were manipulated, just like women, into thinking that they were indeed helping during the war. In these USFA propaganda posters children were urged and attracted to "do their bit" and to "leave nothing on [their] plate (Figure 2)."[8]

Through the use of these types of propaganda advertisements, children were altered to believe that their work would, like their mother's, make the difference needed to beat the "bad guy."

According to Tunc, the Food Administration's posters were the most significant legacy of WWI due to the fact that they were passed down to the Second World War, using "identical gendered language and imagery."[9] The magnitude of these posters, both in numbers and in size were very apparent during the First World War. A building in Baltimore, Maryland, for example, displayed a very long banner requesting the American population to save food because "120 Million Allies Must Eat (Figure 3).[10]" By means of their advertising campaigns, the administration was able to acquire several advertising outlets to showcase the USFA through mediums such as periodicals, newspapers, printed materials, outdoor

Figure 3. Baltimore, Maryland, circa 1917-1918. National Archives Identifier: 512432.

advertising, posters, street and railway coach signs, and advertisements through food companies. It was the majority of the outdoor advertising that was associated with illustrations that contained information that would be both valuable and indicative. Again, we come back to the idea of repetition being used through out the United States in the propaganda that the USFA was producing; the more of the same image or slogan that is seen, the more notable the message becomes. Since much of the involvement of the propaganda dealt with re-educating the public about food production, the use of both visual and print propaganda became imperative for the USFA.

Posters or colored lithographs were mass distributed to convey the conservation methods of the USFA. Many like those in Baltimore displayed a simple message to the public. Some, however, presented more than enough information on how to conserve and why one must save food. Many of the administration's posters such as poster no. 2 stated what needed to be saved and what could be substituted (Figure 4).[11] The United States Food Administration had identified which commodities were to be

Figure 4. "Save and Serve the Cause of Freedom," UCR Special Collections and Archives, Collection 030.

focused on saving: wheat, meat, fats, and sugars. The posters ultimately conveyed the message that if the population saved these commodities, they would be serving the cause of freedom. The USFA also produced posters that provided information as to "what the food situation [was] (Figure 5)."[12] In this particular poster the USFA played on humanitarian sentiments. Though the poster did not have images, it did its job explaining to the public that just because not all are able to go overseas to fight the enemy face to face, it was their duty to help the "fighters fight."

In many instances in this particular poster, the USFA mentioned just how much help was needed through volunteerism. It emphasized that it was "*they* who are doing the fighting, the suffering, the dying – in *our* war," therefore it was our duty to volunteer.[14] There was a presumption that women were those helping in the kitchen, therefore were the ones needed to take this first step. This particular poster was attempting to get the audience, or women, to commit themselves to a role of food conservationist. Hoover believed that tapping into the existing

Figure 5. "Why is it Necessary to Eat Less Meat and Less Wheat Bread?" UCR Special Collections and Archives, Collection 030.

women's network was a necessity in order for them to unite civil society and government propaganda.[15] Though these posters were relatively small compared to the massive banner like that in Baltimore, they were mass distributed. In spite of the fact that it was not possible to keep exact inventory of such advertisements because of the spontaneity of patriotic contributions, approximately $1,284,000 was spent on 53,524 sheet posters alone.[16] A total of $7,582,600 was spent on all sorts of outdoor advertising including signs on federal premises, railroad bulletins, and electronic displays. These poster methods became a way in which propaganda "sought to give housework the illusion of becoming a public activity."[17] Women were not able to escape the aggressiveness of the United States Food Administration or the government's in order to harness the "woman power" of the home front.[18]

Within the Food Administration, the Division of Home Conservation was created to encourage the study of methods of economy in the home for the use and preparations of food.[19] Home economists were assigned to each state to provide help with practical scientific advice on how to conserve and what to substitute. This led to the establishment of an experimental kitchen that provided recipes that would assist women with their substitution for the commodities needed. For example, with the help of the Department of Agriculture, the Conservation Division published wheatless recipes for Baking Powder Loaf Bread (Figure 6) among other types of cookbooks.[20] Not only did this particular cookbook include Loaf Bread recipes, but it also included recipes for muffins, biscuits, and cakes. Again, the propaganda that came from the United States Food Administration dealt a great deal with the notion of gender roles and cookbooks were no exception. With the help of the government, the Division for Home Conservation was able to publish recipes everywhere from pamphlets to newspaper releases, which women were expected to follow. Not only did the Food Administration create cookbooks, but they also endorsed several of the most popular, which would go up in revenue. As Kingsbury mentions, the kitchen became the forefront to the challenges of becoming better homemakers, which further reinforced these gender roles.[21]

Women who were members of the United States Food Administration rallied in public on a "War Bread Truck" for women to try war bread, which they promoted as cheaper. A photograph taken between 1917 and 1918 in Missouri, St. Louis, demonstrates women promoting war bread on city streets and encouraging women to taste and

Figure 6. Wheatless recipes that were tested in the Experimental Kitchen of the Food Administration. The Library of Congress, Call Number: 7312303.
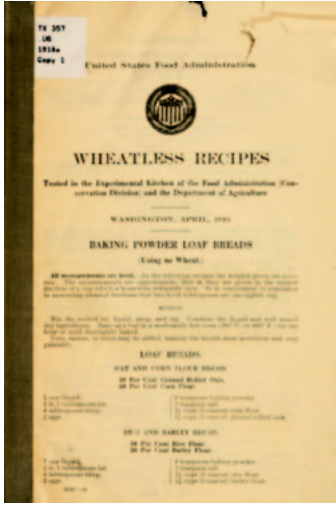
Figure 7. Members of the United States Food Administration on top of a truck promoting War Bread in 1918. National Archives, Record Group 4. Identifier: 283507.

to learn how to make it (Figure 7).[23] This was another way in which women became of use to the USFA. The most prominent feature of the photograph, however, is not the promotion of war bread, but their dress. The nine women standing on top of the War Bread Truck were all wearing the official uniform of the Food Conservation Division of the United States Food Administration. The Hoover Apron, as it was called, not only encouraged women to participate but also worked to promote the USFA's efforts. It was a very important representation of the "professionalism of home economists" and the "modern American homemaker."[24] This uniform proved to be a powerful tool in attracting women to volunteer. Though it was just a piece of clothing, the Hoover Apron became a repeating visual advertisement for the USFA, more specifically to the Conservation Division. In contrast to a paper poster, this type of propaganda allowed women to put on a uniform as if they were actual soldiers, like men at the war front, ultimately making this dress more effective. It represented their "army" and their cause, which further authenticated the USFA and their goals of conservation.

Archival research at the UCR Special Collections, augmented by material elsewhere illustrates the many types of propaganda directed towards women during the First World War. Propaganda such as pledge cards and WWI posters, in particular to those found at UCR Special Collections helped elaborate on the importance of examining the kind of manipulative tactics utilized

towards women. In the case of the United States Food Administration, propaganda infiltrated all aspects of American life, "from production, to consumption, to dietary modifications."[25] Because women were the initial intended audience, the idea of volunteerism was well utilized in their aggressive campaigning techniques, shaping our ideas of distributing information by way of propaganda. For women, volunteering meant adding to their efforts through the domestic sphere, which managed to increase their social mobility even further, even if only enclosed by traditional and social constructed gender roles. The connection between domestic and military space are in part what makes propaganda of the period so effective and so suggestive of the home's changing importance.[26] Through the use of publicity and advertisements, the United States Food Administration was able to institute women as "household soldiers," where the exploitation of their role as women helped drive their importance to the conservation program and the home front. With the utilization of these propaganda posters, pledge cards, and cookbooks, the United States Food Administration was able to provide an aspect of propaganda strategies that was not seen until the First World War.[27]

Footnotes

1 William Clinton Mullendore, *History of the United States Food Administration* (Stanford University Press; London, H. Milford, Oxford University Press, 1941), 12.

3 Celia Malone Kingsbury, *For Home and Country* (University of Nebraska Press, 2010), 19-20.

4 United States Food Administration, "Member of United States Food Administration." Home/ Pledge card by the USFA. UCR Rivera Library Special Collections and Archives, Collection 030.

5 Stephen Ponder, "Popular Propaganda: The Food Administration in World War I," *J&MC Quarterly* 72, No. 3 (1995), 542.

6 Ponder, "Popular Propaganda," 542.

7 Kingsbury, *For Home and Country,* 169.

8 "Little Americans Do Your Bit," poster by Cushman Parker.

9 Tanfer Emin Tunc, "Less Sugar, More Warships: Food as American Propaganda in the First World War," *War in History* 19, No. 2 (2012), 216.

10 "Baltimore, Maryland, circa 1917-1918." Photograph from Records of the U.S. Food Administration, 1917-1920. National Archives Identifier: 512432.

11 United States Food Administration, "Save and Serve the Cause of Freedom." UCR Rivera Library Special Collections and Archives, Collection 030.

12 United States Food Administration, "Why it is Necessary to Eat Less Meat and Less Wheat Bread?" UCR Rivera Library Special Collections and Archives, Collection 030.

13 Ibid.

14 Ibid.

15 Tunc, "Less Sugar, More Warships," 199.

16 Mullendore, *History of the United States Food Administration*, 89.

17 Marsha Gordon, "Onward Kitchen Soldiers: Mobilizing the Domestic During World War I," *Canadian Review of American Studies*, 29, No. 2 (1999), 63.

18 Ibid., 62.

19 Mullendore, *History of the United States Food Administration,* 100.

20 United States Food Administration, "Wheatless Recipes: Baking Powder Loaf Breads," April 1918. The Library of Congress, Call Number: 7312303.

21 Kingsbury, *For Home and Country*, 30.

22 Joan L. Sullivan, "In Pursuit of Legitimacy: Home Economists and the Hoover Apron in the World War I," *Dress*, Volume 26 (1999), 38.

23 Missouri State Food Administration, "Missouri Women Demonstrate War Bread on City Streets, St. Louis, ca.1917 – ca.1918." National Archives Identifier: 283507, Record Group 4.

24 Sullivan, "In Pursuit of Legitimacy," 31.

25 Tunc, "Less Sugar, More Warships," 214.

26 Gordon, "Onward Kitchen Soldiers," 68.

27 Sullivan, "In Pursuit of Legitimacy," 32.

University Students' Attitudes and Behaviors Towards Cognitive Enhancement Drugs

Nicole J. Perez[1,2], Kate Sweeny[2]

[1]*Department of Music*
[2]*Department of Psychology*

ABSTRACT

Cognitive enhancement drugs (CEDs), such as Adderall® or Ritalin®, used in the treatment of ADHD, have gained popularity amongst college students for their presumed cognitively enhancing abilities. Thus, the current study represents an initial effort to identify predictors of attitudes toward CEDs and caffeine use for the purpose of academic achievement in a large western university. Participants ($N = 118$, diverse undergraduate sample) completed an online questionnaire including measures of demographics, personality, academic characteristics and habits, and perceptions of caffeine and CED use. Results depict personality type and demographics are correlated to specific views towards CEDs. These findings confirm variability in attitudes toward CED use and identify predictors of these attitudes to aid in effective interventions.

Keywords: University, Cognitive Enhancement, Student, Substance Abuse

FACULTY MENTOR

Kate Sweeny

Department of Psychology

Professor Sweeny is an Associate Professor of Psychology. Her research examines two broad questions. First, how do people cope with uncertain waiting periods? Second, how should doctors talk to their patients? She has studied law graduates awaiting news about the bar exam, patients awaiting biopsy results, researchers awaiting manuscript decisions, surgeons talking to their adult patients, and asthma specialists talking to pediatric patients, among many other topics and studies.

AUTHOR

Nicole J. Perez

Department of Music
Department of Psychology

Nicole J. Perez is a third year Honors student currently double majoring in Psychology and Music. She has research interests within Health Psychology including drug use and abuse and healthcare practices. Through the Chancellor's Research Fellowship, she has researched student use of cognitive enhancement drugs. As a research assistant in the Life Event's Lab, she has interviewed breast biopsy patients on their hospital experience. She plans to pursue graduate studies in Clinical Psychology to become a clinician for the underserved community of Los Angeles.

Nicole J. Perez

Cognitive enhancement drugs (CEDs) refers to any psychostimulant prescription medication with the function of enhancing mental processes in order to create clearer and more efficient cognitive functioning. These medications are usually prescribed in the form of Adderall® or Ritalin® to treat disabilities such as ADD and ADHD in hopes of improving focus and efficiency in functioning usually inhibited by these disorders. These enhancers, however, have become popular in cosmetic pharmacology due to their presumed abilities to increase focus and productivity in people without diagnosed attention disorders. One controversial population in which these CEDs are becoming popular is university students. Studies show illicit usage rates among college students range from 16% (McCabe et al; as cited in DeSantis, Webb, & Noar, 2008) to as high as 39% (Franke, Lieb, & Hildt, 2012). Qualitative studies of student perceptions have found the social stigma typically associated with drug use did not apply to CEDs, which were accepted and even encouraged in intense academic environments (Aikins, 2011). Additionally, research suggests that students' top reasons for CED use are staying awake to study (72%) and help concentrating (66%; DeSantis et al., 2008). These testimonials and empirical attention have also brought with them many questions: What neurological effects do these drugs really have and what do students think of them on major college campuses? The idea of psychostimulants in the academic setting may be problematic for legal, ethical, and health reasons. First, the use of CEDs is illegal without a prescription. This legal consideration is concerning because students attaining these drugs have to go through an "underground" access system, exposing them to other risky behaviors and leaving them without proper knowledge of the drug. Additionally, there are ethical concerns about the advantage CEDs may provide and whether use of CEDs to enhance studying or test taking should be considered academic cheating. In previous studies students have expressed concerns because caffeine is freely accessible to everybody, stimulants are not, and this implies a lack of equal opportunities (Franke, Lieb, & Hildt, 2012). These drugs might make an already uneven playing field for many students, particularly socioeconomically disadvantaged students, even more unfair, as CEDs favor those who can afford to purchase them (Cakic, 2009). To make matters worse, little is known about the side effects of most psychostimulant drugs;

however, they are classified as Schedule II controlled substances with a high risk for abuse (U.S. Department of Justice, 2014). Furthermore, abuse of these substances has been associated with stroke, cardiac arrest, violence, and suicidal tendencies (Aikins, 2011).

When one considers the growing popularity of these substances and the concerns associated with their use, the need to identify student populations that may be most prone to CED use is clear. Thus, the current study seeks to reveal demographics, personality traits, and academic habits that are predictors of students' attitudes toward CED use in order to begin to understand students' attitudes related to this habit. Based on previous research, we hypothesized that students who are more involved in campus activities, who are engaged in more rigorous academic tracks, and who are competing to seek graduate education would have more negative (i.e., less permissive) views towards CEDs as opposed to students who are not involved in campus activities, who do not consider academics a major part of their life, and who plan to work immediately following graduation (Emanuel, 2013; DeSantis et al., 2008). We also explored the role of demographic factors, involvement in specific campus activities (i.e., Honors, student clubs, Greek system), and personality as predictors of students' attitudes toward CEDs.

METHOD

Participants

Participants (N = 203; 72% female, M_{age} = 19.41) were undergraduate students recruited from the UCR Psychology department's subject pool and through an email via the Honors program. Participants completed the survey at their leisure, and students enrolled in psychology courses received partial course credit for completing the study. The sample identified as 35.5% Asian, 32.7% Hispanic/Latino, 21.3% White/Caucasian (not Hispanic/Latino), 3.3% Black or African-American, 1.0% Native Hawaiian or other Pacific Islander, and 6.2% multiple.

Regarding academic characteristics, 53.5% of the sample was part of the College of Humanities, Arts, and Social Sciences (CHASS); 33.7% were part of the College of

Natural and Agricultural Sciences (CNAS); 8.5% were part of the Bourns College of Engineering (BCOE); 0.5% (1 person) was part of the School of Business Administration; and 3.8% were part of multiple colleges. Regarding campus activities, 71.6% of the sample indicated that they were involved in at least one campus activity (e.g., honors, Greek system, clubs).

Procedure

Participants followed a link to an online survey, which included a consent form and the primary questionnaire. The questionnaire consisted of four parts assessing demographics, personality, academic characteristics, and attitudes toward and beliefs about CED use.

Demographics. We first asked participants three general demographics questions: age, gender, and race/ethnicity. Regarding race and ethnicity, the largest groups in the sample were Hispanic/Latino students (33%) and Asian students (36%). Other groups were too small for reliable comparison, so we targeted comparisons between Hispanic/Latino students versus all others, and between Asian students and all others.

We then asked six academic demographic questions: major, college, GPA, year in school, involvement in campus activities (e.g., clubs, sororities, organizations; coded as either "0" for no campus activities or "1" for involvement in at least one activity), and plans after graduation (e.g., work, graduate school). Given the predominance of CHASS (54%) and CNAS majors (34%), we focused comparisons between academic tracks on these two groups. Regarding post-graduate plans, we focused on comparisons between participants who indicated that they planned to work (or not) and comparisons between participants who indicated that they planned to attend graduate school (or not).

Personality. Participants completed the 44-item Big Five Personality Inventory (John, Donahue, & Kentle, 1991; John, Naumann, & Soto, 2008), which includes subscales assessing openness (Cronbach's $\alpha = .78$), conscientiousness (Cronbach's $\alpha = .77$), extroversion (Cronbach's $\alpha = .84$), agreeableness (Cronbach's $\alpha = .82$), and neuroticism (Cronbach's $\alpha = .80$).

Academic characteristics. Participants responded to four items about their academic habits, each with a simple yes or no. Two questions asked about caffeine use in academics ("I have used caffeine…at some point in my college career to study for exams, write essays, or complete school projects," "I have used caffeine…during the past year to study for exams, write essays, or complete school projects"), and two questions asked about CED use ("I have used cognitive enhancement drugs (e.g., Adderall, Ritalin) at some point in my college career to study for exams, write essays, or complete school projects," "I have used cognitive enhancement drugs…in the past year to study for exams, write essays, or complete school projects"). Questions about caffeine use were included to assess students' perceptions of a legal substance that is widely used and generally acceptable (caffeine), in comparison to their perceptions of illicit prescription drugs that serve a similar academic purpose (CEDs). Specifically, items about recent caffeine use were intended to assess willingness to use substances for academic enhancement, even if people denied using CEDs for that purpose (whether honestly or dishonestly).

Attitudes toward CED and caffeine use. Finally, participants responded to nine questions assessing their attitudes toward CED and caffeine use in academic settings. Four questions asked about perceptions of cheating ("The use of [cognitive enhancement drugs like Adderall or Ritalin / caffeine] to enhance performance during an exam is cheating," "The use of [cognitive enhancement drugs like Adderall or Ritalin / caffeine] to prepare for an exam is cheating"; 1 = *strongly disagree*, 7 = *strongly agree*), and responses on these items were averaged to create a measure of cheating perceptions (Cronbach's $\alpha = .75$). Again, items about caffeine were included to broadly assess permissiveness toward use of substances for academic enhancement.

Three questions asked about perceptions of moral, medical, and legal differences between CEDs and caffeine ("There is a [moral / medical / legal] difference between the use of caffeine versus the use of drugs like Adderall or Ritalin for cognitive enhancement when studying or taking an exam"; 1 = *strongly disagree*, 7 = *strongly agree*), and these three items were averaged to create a measure of perceptions of

a distinction between CEDs and caffeine (Cronbach's α = .59). These items used caffeine as a comparison standard for perceptions of CEDs because although they can be used for similar purposes, some students may draw a distinction between legal (caffeine) and illicit drugs (CEDs, if used without a prescription). A failure to distinguish between these substances would indicate relative permissiveness toward CEDs.

Two final questions asked about the degree to which participants perceive CEDs as a problem on campus ("I believe that many students use cognitive enhancement drugs like Adderall and Ritalin on this campus"; 1 = *strongly disagree*, 7 = *strongly agree*) and in general ("I believe that the use of cognitive enhancement drugs like Adderall and Ritalin is a series problem facing universities"; 1 = *strongly disagree*, 7 = *strongly agree*).

RESULTS

Independent samples *t*-tests, and bivariate correlations were used to examine relationships between predictors (demographics, personality, and academic characteristics) and attitudes toward CED use. The study found significant correlations between the predictors and attitudes towards CED use in all categories tested. Turning first to demographic predictors, women ($M = 2.69$, $SD = 1.21$) were less likely than men ($M = 3.13$, $SD = 1.43$) to see use of CEDs as cheating $t(193) = 2.13$, $p = .03$, $d = .31$. Additionally, Latino students ($M = 4.96$, $SD = 1.24$) were less likely than other racial or ethnic groups ($M = 5.36$, $SD = 1.28$) to make a distinction between CED and caffeine use, $t(189) = 2.01$, $p = .046$, $d = .29$, and Latino students ($M = 4.00$, $SD = 1.62$) were also less likely than other racial/ethnic groups ($M = 4.53$, $SD = 1.80$) to see use of these substances as a problem on campus, $t(188) = 1.97$, $p = .05$, $d = .29$. Asian students did not differ from other students in their perceptions of CED use.

Turning next to personality predictors, more extraverted students were more likely to see CED and caffeine use as distinct, $r(191) = .19$, $p = .009$, and were less likely to see use of CEDs as cheating, $r(195) = -.16$, $p = .03$. Similarly, more agreeable students were also less likely to see use of

CEDs as cheating, $r(195) = -.18$, $p = .01$. Further findings show that more conscientious students believed that use of these substances on campus is relatively low, $r(190) = -.17$, $p = .02$, whereas students higher in neuroticism believed that use is relatively high, $r(190) = .15$, $p = .04$.

Considering academic characteristic, students in the College of Natural and Agricultural Sciences ($M = 3.15$, $SD = 2.62$) were more likely to see use of these substances as cheating than were students in the College of Humanities, Arts, and Social Sciences ($M = 2.62$, $SD = 1.11$), $t(169) = 2.62$, $p = .01$, $d = .40$. Also, students involved in campus activities (e.g., clubs, honors societies, sports; $M = 2.97$, $SD = 1.33$) were more likely than students not involved in activities ($M = 2.39$, $SD = 1.07$) to see these behaviors as cheating, $t(193) = 2.83$, $p = .005$, $d = .41$, and students involved in activities ($M = 5.40$, $SD = 1.22$) were also more likely than students not involved in activities ($M = 4.79$, $SD = 1.33$) to draw a distinction between CED and caffeine use, $t(189) = 2.98$, $p = .003$, $d = .43$. Students who planned to work after graduation (38% of sample; $M = 4.94$, $SD = 1.41$) were less likely than other students ($M = 5.40$, $SD = 1.16$) to draw a distinction between caffeine and CED use, $t(189) = 2.42$, $p = .02$, $d = .35$.

Finally, we examined relationships between use of caffeine for academic purposes and attitudes toward caffeine and CED use. Reports of personal CED use were too rare to examine effectively (4.1% of the sample reported using in the past year, $n = 8$), although this rate of use is entirely consistent with a nationwide survey of non-medical use of CEDs among college students (4.1%; McCabe, Knight, Teter, & Wechsler, 2005). As anticipated, students who personally use caffeine to help them academically (73% of sample; $M = 2.61$, $SD = 1.15$) were less likely than students who do not use caffeine for this purpose ($M = 3.36$, $SD = 1.49$) to see these behaviors as cheating, $t(193) = 3.69$, $p = .0003$, $d = .53$. Also as hypothesized, students who personally use caffeine to help them academically ($M = 4.44$, $SD = 1.65$) were more likely than students who do not use caffeine for this purpose ($M = 3.80$, $SD = 1.52$) to believe that use of these substances on campus is relatively high, $t(188) = 2.38$, $p = .02$, $d = .35$.

DISCUSSION

The goal of the current study was to gain an initial understanding of the personality traits, demographics, and academic characteristics that predict opinions towards the use of cognitive enhancement drugs (CEDs). First, our findings are consistent with our hypothesis that students involved in campus activities would be less permissive in their views towards CED use, both in their harsher views of CEDs as cheating and in the stronger distinction they drew between caffeine and CED use for academic enhancement. Although we know of no previous studies that have examined the relationships between campus engagement and views of CEDs, we suspect that students who are more involved on campus are more aware of their campus community and also tend to be more academically involved and therefore, more academically competitive, which may explain their less permissive views toward academic "enhancements."

Second, our finding that students in the College of Natural and Agricultural Sciences (CNAS) are more likely than students in the College of Humanities, Arts and Social Sciences (CHASS) to see the use of CEDs as cheating is consistent with our hypothesis that students in more (stereotypically) rigorous academic tracks would be more likely to see CED use as cheating. This finding is also consistent with previous findings: In one survey, fifty percent of premedical students saw the use of CEDs for academic advancement as a major problem (Emanuel et al., 2013). In the case of our sample, the grading in many CNAS classes is curved, thus creating greater competition among students. In fact, one CNAS participant in our study commented, "If steroids are not allowed in sports then neither should these drugs," highlighting a competitive mentality.

Third, although there was no direct evidence to support our hypothesis that students seeking graduate education have more negative views toward CED use, we did find evidence to support our related hypothesis that those seeking work after graduation would have more permissive views. Results showed that students who planned to work directly after graduation were less likely to differentiate between caffeine and CEDs, such that they saw these substances as essentially equivalent from a legal, medical, and social perspective. This lack of distinction could lead to the belief that taking CEDs for academic enhancement is not a problem for these students, given that caffeine is largely viewed as socially, medically, and legally acceptable. This "slippery slope" is supported by previous studies, which revealed that students were so focused on the legal distinction between CEDs and other academic enhancements that when prompted with the possibility of CEDs being fully legalized, they overwhelmingly indicated that they would see no further ethical problem with their use (Franke et al., 2012). The more permissive views of students who plan to work after graduation may indicate that these students do not perceive their classmates actions as affecting their personal success, as indicated by the comment of one student who plans to work after college: "This is entirely up to the person doing it, and how they will view themselves after it is done."

We also explored demographic predictors of opinions toward CED use. We found that women were more permissible than men toward CED use. This finding conflicts with previous research conducted with both undergraduate students (McCabe et al., 2005) and medical students (Emanuel et al., 2013), which found that male students were more likely to use CEDs than were female students. Because we focused on attitudes toward rather than use of CEDs, it may be that women's attitudes toward CEDs use are more permissive, but this openness does not translate to personal use. Future research can specifically address the possible disconnect between attitudes and use, with an eye toward gender differences in this regard.

We also found that Latino students were more permissible toward CED use compared to other students and that Latino students were less likely than other students to believe that CED use is a problem on campus. A nationwide survey of college students found that White students were most likely to report use of CEDs, but this survey included so few Latino participants, the authors simply lumped them in with "Other" (comparison groups were Black or African American and Asian). Thus, the particular diversity of our sample provides a rare look at the attitudes and beliefs of Latino students regarding CEDs. Given the limited research on racial and ethnic differences in attitudes toward the use of CEDs, future research that targets diverse student samples will be crucial in moving these questions forward.

Furthermore, we found that more extroverted and agreeable students were more permissive of CED use. These traits tend to be more social and include facets such as sociability, positive emotion, sympathetic, not finding fault with others, and compliance (John, Naumann, & Soto, 2008), which might explain their relationship with more permissive attitudes toward others' behavior. Students who were higher in neuroticism were no more or less permissive than other students in their attitudes, but they did perceive CED use to be relatively high on campus. This trait is associated with anxiousness (John, Naumann, & Soto, 2008), so perhaps these students are worried about CED use on campus simply because they tend to be worriers in general. In contrast, and somewhat surprisingly given that conscientiousness has been linked to perceptiveness and deliberation (John, Naumann, & Soto, 2008), more conscientious students believed CED use was relatively low on campus. Although we might have anticipated that conscious students would have heightened sensitivity regarding illicit academic activities, we suspect that their perceptions of low use might be due to their reference group. That is, perhaps conscious students tend to spend time with other conscious students, who are relatively unlikely to use CEDs and other illicit drugs.

This study was largely exploratory, with the goal of revealing initial insights into students' perceptions of an increasingly common (but somewhat illicit) strategy for academic success. The study had a number of strengths, including a relatively large and diverse sample and a broad approach to identifying predictors of attitudes toward CED use. However, our findings are limited to a single campus and did not seek direct testimony from a significant sample of CED users. Further studies could advance our research questions through implementing similar approaches at different universities or including interviews specifically with students who use CEDs for academic purposes. Ultimately, this study serves as a precursor for more research of its kind and gives a glimpse at the demographics, personality traits, and academic characteristics that might lead to acceptance of this controversial, and potentially dangerous, behavior in university settings. Our findings also point to possible solutions by targeting the correct student populations with awareness and prevention programs.

REFERENCES

Aikins, R. D. (2011). Academic performance enhancement: A qualitative study of the perceptions and habits of prescription stimulant-using college students. *Journal of College Student Development, 52,* 560-576.

DEA / Drug Scheduling. (n.d.). Retrieved from http://www.justice.gov/dea/druginfo/ds.shtml

DeSantis, A. D., Webb, E. M., & Noar, S. M. (2008). Illicit use of prescription ADHD medications on a college campus: A multimethodological approach. *Journal of American College Health, 57,* 315-323.

Emanuel, R. M., Frellsen, S. L., Kashima, K. J., Sanguino, S. M., Sierles, F. S., & Lazarus, C. J. (2013). Cognitive enhancement drug use among future physicians: Findings from a multi-institutional census of medical students. *Journal of General Internal Medicine, 28,* 1028-1034.

Franke, A. G., Lieb, K., & Hildt, E. (2012). What users think about the differences between caffeine and illicit/prescription stimulants for cognitive enhancement. *PLoS ONE, 7,* e40047.

John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative big-five trait taxonomy: History, measurement, and conceptual issues. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.), *Handbook of personality: Theory and research* (pp. 114-158). New York, NY: Guilford Press.

John, O. P., Donahue, E. M., & Kentle, R. L. (1991). *The Big Five Inventory—Versions 4a and 54.* Berkeley, CA: University of California, Berkeley, Institute of Personality and Social Research.

John, O., & Robins, R. (2008). *Handbook of personality: Theory and research (3rd ed.).* New York: Guilford Publications.

McCabe, S. E., Knight, J. R., Teter, C. J., & Wechsler, H. (2005). Non-medical use of prescription stimulants among US college students: Prevalence and correlates from a national survey. *Addiction, 100,* 96-106.

Teter, C. J., McCabe, S. E., LaGrange, K., Cranford, J. A., & Boyd, C. J. (2006). Illicit use of specific prescription stimulants among college students: Prevalence, motives, and routes of administration. *Pharmacotherapy, 26,* 1501-1510.

The Role of Religiosity and Spirituality in Waiting Experiences

Maria D. Ramirez Loyola, Kate Sweeny

Department of Psychology

ABSTRACT

Despite the ubiquity of stressful waiting periods (e.g., after a job interview, diagnostic test, midterm exam), we know little about these waiting experiences or about individual differences in these experiences. Although studies have documented differences in personal waiting experiences, as well as tips for navigating waiting periods, research has not yet investigated the role of religiosity or spirituality in waiting experiences. To examine this question, participants (N = 200) were recruited through Amazon's Mechanical Turk to complete a questionnaire that included measures of their religious and/or spiritual beliefs. Participants then reflected on their experiences awaiting uncertain news and reported their typical thoughts and feelings during these experiences. Initial findings indicate that people who are more religious and/or spiritual are less likely to engage in information avoidance, more likely to see the silver lining in a bad outcome, and more likely to embrace a hopeful, optimistic attitude during waiting periods. These findings suggest that religious and spiritual beliefs might help people navigate uncertain waiting periods by providing them with a sense of comfort and confidence that everything will eventually work out in the end. A better understanding of the role of religion and spirituality in waiting experiences may reveal opportunities to target interventions appropriately to reduce distress during stressful waiting periods.

Keywords: religion/spirituality, waiting experience, uncertainty, emotion

AUTHOR
Maria D. Ramirez Loyola

Department of Psychology

Maria Ramirez Loyola is a third year Psychology major. During her time at UCR, Maria has worked as a research assistant in various laboratories on campus including Dr. Sweeny's Life Events Lab. As of now, her research has focused on waiting experiences and possible predictors of individual differences. As a member of the University Honors Program, Maria has served as a student staff member and discussion leader. She plans to pursue a Ph.D. in social psychology and continue teaching in the future.

FACULTY MENTOR

Kate Sweeny

Department of Psychology

Professor Sweeny is an Associate Professor of Psychology. Her research examines two broad questions. First, how do people cope with uncertain waiting periods? Second, how should doctors talk to their patients? She has studied law graduates awaiting news about the bar exam, patients awaiting biopsy results, researchers awaiting manuscript decisions, surgeons talking to their adult patients, and asthma specialists talking to pediatric patients, among many other topics and studies.

Maria D. Ramirez Loyola

THE ROLE OF RELIGIOSITY AND SPIRITUALITY IN WAITING EXPERIENCES

Waiting is something that people take part in multiple times every day, and yet very few people are aware of how much time they actually spend waiting. For example, people wait in lines, they wait on their way from place to place (e.g. in traffic, at cross walks or street lights), and they wait to hear back from potential romantic partners. This being said, not every waiting situation is the same (Sweeny, 2012), and people tend to wait for different things in different ways (Sweeny & Cavanaugh, 2012; Sweeny & Andrews, 2014). For example, consider the difference between a waiting experience in which one knows beforehand what the outcome of the situation will be (e.g., waiting at a street light that will eventually turn from red to green) and one in which the result is uncertain (e.g., waiting to see if a potential romantic partner will respond positively or negatively to a date invitation). Clearly, waiting for uncertain news when one runs the risk of either receiving good news (the request for a date is accepted) or bad news (the request is declined) produces a vastly different experience then waiting for a street light to turn green. However, despite the overabundance of uncertain waiting periods in everyday life (e.g., after a job interview, diagnostic test, midterm exam), researchers know little about these waiting experiences or about individual differences in these experiences.

The few existing studies aimed at exploring individual differences in a variety of uncertain personal waiting situations including waiting for health related information (Cavanaugh & Sweeny, 2012; Sweeny & Dillard, 2014), election results (Krizan & Sweeny, 2014), midterm exam grades (Sweeny & Shepperd, 2010), and the results of the California bar exam (Sweeny & Andrews, 2014; Sweeny & Falkenstein, *under review*). However, most of these studies have focused on the process of how people experience and manage uncertain waiting periods instead of focusing on individual differences in the waiting experience (e.g. personality type, education level, socioeconomic status; see Sweeny & Andrews, 2014 for an exception). Consequently, an emphasis has been placed on developing tips for navigating uncertain waiting periods in order to develop models that can be used to target interventions

appropriately to reduce distress during stressful waiting periods (Sweeny, 2012; Sweeny et al., *under review*) without full consideration of how these interventions should be targeted for people with different backgrounds or beliefs.

Specifically, no research to date has examined the role of religious and spiritual beliefs on the experience of awaiting uncertain news, despite the clear relevance of these beliefs for waiting experiences. For example, it is likely a very different experience to wait for uncertain news when one believes that "everything happens for a reason" because a higher power is in control of the outcome than when a person does not believe in a higher power and outcomes are seen as chance events. The present study examined the role of these beliefs in people's reports of their emotional, cognitive, and behavioral experience during typical waiting periods in their lives. We hypothesized that self-identified religious and/or spiritual participants (independently of specific affiliation) would report less distress during typical waiting periods. We also hypothesized that these same participants would report using different emotion regulation strategies (e.g., more likely to see a silver lining, less likely to suppress their emotions) during waiting periods compared to those participants with no reported religious and/or spiritual affiliation (i.e., self-reported atheists/ agnostics). We also hypothesized that among people who believe in a God or gods, those who view their higher power as more compassionate and benevolent would report less distress during waiting experiences.

METHOD

Participants

Workers on Amazon's Mechanical Turk (mTurk) survey site ($N = 200$, 44% women, $M_{age} = 33.2$, all at least 18 years old) earned $1.00 for completing an online survey that included measures of religious beliefs, a prompt to consider what they typically experience when they await uncertain news, and a version of the Waiting Experiences Inventory (See Sweeny & Andrews, 2014). Amazon's mTurk system is a cost-effective resource for recruiting a diverse sample of participants in fully online studies, particularly compared to the undergraduate samples typically used in psychology. The sample consisted primarily of participants identifying

as White/Caucasian (74%) but also participants identifying as Hispanic/Latino (10%), Asian (7%), Black or African-American (5%), Native American (1%), or multiple (3%).

PROCEDURE

After completing consent procedures, participants were directed to the SurveyMonkey questionnaire through Amazon's mTurk site. Once there, participants first completed measures of their religious and spiritual beliefs (see below for details). The survey then provided the participants with examples of uncertain waiting periods, such as waiting for results of a medical test, hearing back after an interview, news about layoffs or promotions, or a grade on an exam. Then they were prompted to think about times when they had waited for uncertain news throughout the course of their lives. After this step, they were prompted to indicate how they typically experienced uncertain waiting periods using measures based on the uncertainty navigation model (Sweeny & Cavanaugh, 2012; see below for details).

Measures

Religious affiliation. Participants first indicated their religious affiliation from a list of possible affiliations (an open-ended option was also included). Participants' affiliations were as follows: 29% Protestant, 16% Catholic, 3% Buddhist, 1% Hindu, 1% Jewish, 26% Agnostic, 20% Atheist, and 4% other. For the purpose of our analyses, we compared participants who indicated any religious affiliation (54.5%) with participants who indicated they were agnostic or atheist (45.5%).

Measures of religious commitment. We assessed religious commitment as a composite of several measures, including single item measures of religiosity and spirituality ("How religious are you?" 1 = *not at all religious*, 7 = *very religious*; "How spiritual are you?" 1 = *not at all spiritual*, 7 = *very spiritual*), an 11-item religious commitment inventory (Miller, Shepperd, & McCullough, 2013; e.g., "I often read books and magazines about my faith," "Religious beliefs influence all my dealings in life"; 1 = *not at all true of me, 5 = totally true of me*), and four items assessing frequency of religious behaviors (e.g., "In the past 6 months, how often did you read the holy text associated with your religion?"

1 = *never*; 9 = *more than once a day*). We standardized scores on each item and then averaged those scores to create an overall measure of religious commitment (Cronbach's α = .92).

Views of god. Participants indicated (yes / no) whether they believed in a God or gods, and those who responded "yes" (54%) were then prompted to respond to a 14-item scale assessing their views of god(s) as either punitive or loving (Shariff & Norenzayan, 2011; e.g., loving, punishing, gentle, terrifying; 1 = *not at all characteristic*, 7 = *completely characteristic*). After reverse-scoring the punitive items, we averaged responses to create a composite (Cronbach's α = .86).

Waiting experiences inventory. Researchers have developed a set of questions regarding waiting experiences (the waiting experience inventory, WEI; Sweeny & Andrews, 2014; Sweeny et al., *under review*) that can be adapted depending on the needs of a particular study. In the present study, items from the WEI were worded to inquire about typical waiting experiences.

Emotions. Participants indicated how anxious they typically feel during waiting periods on 10 items (e.g., "During uncertain waiting periods, I typically feel worried," "I typically feel anxious every time I think about uncertain news"; 1 = *strongly disagree, 5 = strongly agree*; Cronbach's α = .94). Participants also indicated how much they typically feel other emotions, including happy, pleased, angry/hostile, frustrated, depressed/blue, joyful, enjoyment/fun (Fredrickson et al., 2003; after reverse-scoring positive emotions, Cronbach's α = .79).

Rumination. Participants indicated how much they typically ruminate during uncertain waiting periods on three items ("During uncertain waiting periods, how often do you typically think about the uncertain news?" "…bring up the uncertain news in conversation with other people?" "…find yourself unable to stop thinking about the uncertain news?" 1 = *not at all,* 5 = almost constantly; Cronbach's α = .82).

Distraction and suppression. Participants responded to one item assessing how much they typically try to distract themselves (1 = *strongly disagree, 5 = strongly agree*) and

two items assessing how much they typically try to suppress their emotions ("I typically try to stop myself from thinking about the uncertain news," "I typically try to hide my feelings about the uncertain news from other people"; 1 = *strongly disagree, 5 = strongly agree*; Cronbach's α = .44).

Preparing for bad news. Participants responded to one item assessing how much effort they typically put toward trying to minimize problems that would occur if the news is bad (i.e., objective consequence mitigation; 1 = *very little effort,* 5 = *a great deal of effort*) and one item assessing how much time they typically spend thinking about how they would cope if the news is bad (i.e. anticipatory coping; 1 = *very little time,* 5 = *a great deal of time*).

Expectation management. Participants responded to two items assessing how much they typically brace for the worst during waiting periods ("I typically brace for the worst when it comes to uncertain news," "I typically want to make sure I keep my expectations low when it comes to uncertain news"; 1 = *strongly disagree,* 5 = *strongly agree*; Cronbach's α = .65) and two items assessing how much they instead try to be hopeful and optimistic (1 = *strongly disagree,* 5 = *strongly agree*; Cronbach's α = .74).

Preemptive benefit finding and distancing. Participants responded to one item assessing whether they typically try to focus on good things that might come from bad news and one item assessing their efforts to downplay potentially bad news (i.e., distancing; for both, 1 = *strongly disagree,* 5 = *strongly agree*).

Information avoidance. Participants responded to one item assessing their information behavior during typical waiting periods ("To what extent do you typically seek or avoid information about uncertain news during waiting periods?" 1 = *consistently seek,* 4 = *neither avoid nor seek,* 7 = *consistently avoid*).

RESULTS

Table 1 presents relationships between religious and spiritual beliefs and reports of typical waiting experiences. On the left side of Table 1 are bivariate correlations between religious commitment and views of god(s) on the one hand and waiting experiences on the other, and the right side presents independent samples *t*-tests comparing religiously affiliated participants to those who were agnostic or atheist. Although most waiting experiences were unrelated to religious and spiritual beliefs, some notable findings arose.

Table 1: Relationships between Religious Beliefs and Waiting Experiences

	Religious Commitment	Views of God(s)	Religiously Affiliated	Atheist or Agnostic		
	r	r	M (SD)	M (SD)	t	d
Anxiety	-.07	-.05	3.39 (1.03)	3.62 (.90)	1.53	.24
Negative emotion	-.05	-.20†	3.32 (.65)	3.36 (.71)	.39	.06
Rumination	.08	-.01	3.31 (.93)	3.27 (.87)	.25	.04
Distraction	-.07	-.09	3.64 (.96)	3.76 (.98)	.79	.12
Suppression	.02	-.10	3.41 (.91)	3.32 (.95)	.65	.10
Objective consequence mitigation	.15†	-.09	3.57 (.95)	3.29 (1.12)	1.59	.28
Anticipatory coping	.16*	.06	3.45 (1.04)	3.32 (1.20)	.73	.12
Bracing	-.11	-.08	3.41 (.97)	3.62 (1.01)	1.33	.21
Hope/optimism	.21**	.16	3.97 (.95)	3.69 (1.01)	1.85†	.29
Preemptive benefit finding	.16*	.15	3.66 (1.13)	3.21 (1.28)	2.39*	.37
Distancing	.12	.21*	3.71 (1.02)	3.38 (1.21)	1.89†	.29
Information avoidance	-.20**	.07	3.29 (1.30)	3.40 (1.44)	.51	.08

Note: †*p* < .10; **p* < .05; ***p* < .01.

Regarding distress during waiting periods, people who reported more positive views of their God or gods said that they experienced somewhat less negative emotion during waiting periods. Contrary to our hypothesis, there was no relationship between religious commitment or religious affiliation and emotions or rumination during the waiting period. Similarly, we found no relationships between religious beliefs and either distraction or emotional suppression.

Turning to efforts to prepare for bad news, participants higher in religious commitment reported both marginally greater efforts to mitigate objective consequences of bad news and greater anticipatory coping during typical waiting periods. Regarding expectation management, as hypothesized, participants higher in religious commitment and who reported a religious affiliation (vs. atheist or agnostic) reported engaging in more positive expectation management (i.e., embracing hope and optimism) during typical waiting periods.

Also as hypothesized, participants higher in religious commitment and who reported a religious affiliation (vs. atheist or agnostic) reported engaging in more preemptive benefit finding. Although we did not have specific hypotheses regarding distancing, participants who reported a religious affiliation (vs. atheist or agnostic) reported engaging in marginally more distancing, and participants who reported more positive views of their God or gods also reported more distancing. Finally, we found that participants higher in religious commitment reported engaging in less information avoidance during waiting periods.

DISCUSSION

The goal of this research was to investigate whether religiosity and/or spirituality predicts differences in the way people experience uncertain waiting periods. Our findings indicate that although they do not experience less distress, people who are more religious and/or spiritual are less likely to engage in information avoidance, more likely to see the silver lining in a bad outcome, and more likely to embrace a hopeful, optimistic attitude during waiting periods. In addition, among people who believe in a God or god(s), those who have more positive views of god(s) reported greater downplaying of the potential bad news and somewhat less negative emotion as they await uncertain news.

These findings are likely due, at least in part, to the effects of believing that a higher power exerts control over all uncertain outcomes and that whatever happens (i.e., whether the news is good or bad), it was meant to happen. Alternatively, it may be that those who reported a religious affiliation (as opposed to being atheist or agnostic) and who reported greater religious commitment have stronger and broader support systems in place, perhaps due to attendance at religious meetings, prayer or meditation groups, and other religious activities, and this social support provides comfort during uncertain waiting periods.

Although these findings provide key initial insights into the role of religious beliefs in waiting experiences, further research on this topic is needed in order to replicate our findings and dig deeper into the process by which religious beliefs exert their effects during waiting periods. This study was strong in its approach to measurement (multiple measures of religiosity, use of validated measures) and generalizability (broad sample), but it was limited by the possibility of memory bias due to the retroactive task of recalling one's typical experiences during waiting periods. Thus, future research should be aimed at examining waiting processes as they unfold, in the midst of a personally important waiting period, and assessing the role of religious and spiritual beliefs (as assessed prior to the waiting period) during these experiences.

A better understanding of the role of religion and spirituality in waiting experiences may reveal opportunities to target interventions appropriately to reduce distress during stressful waiting periods, thereby making uncertain waiting experiences easier to handle for those who need it the most.

REFERENCES

Fredrickson, B. L., Tugade, M., Waugh, C. E., & Larkin, G. R. (2003). What good are positive emotions in crises? A prospective study of resilience and emotions following the terrorist attacks on the United States on September 11th, 2001. *Journal of Personality and Social Psychology, 84,* 365-376.

Krizan, Z., & Sweeny, K. (2013). Causes and consequences of expectation trajectories: "High" on optimism in a public referendum. *Psychological Science, 24,* 706-714.

Miller, W. A., Shepperd, J. A., & McCullough, M. E. (2013). Evaluating the religious commitment inventory for adolescents. *Psychology of Spirituality & Religion, 5*, 242-251.

Shariff, A. F., & Norenzayan, A. (2011). Mean gods make good people. *International Journal for the Psychology of Religion, 21,* 85-96.

Sweeny, K. (2012). Waiting well: Tips for navigating painful uncertainty. *Social and Personality Psychology Compass, 6,* 258-269.

Sweeny, K. & Andrews, S.E. (2014). Mapping individual differences in the experience of a waiting period. *Journal of Personality and Social Psychology, 106,* 1015-1030.

Sweeny, K., & Cavanaugh, A. G. (2012). Waiting is the hardest part: A model of uncertainty navigation in the context of health. *Health Psychology Review, 6*, 147-164.

Sweeny, K., & Dillard, A. (2104). The effects of expectation disconfirmation on appraisal, affect, and behavioral intentions. *Risk Analysis, 34,* 711-720.

Sweeny, K., & Falkenstein, A. (2015). *Is waiting really the hardest part? Comparing the emotional experiences of awaiting and receiving bad news.* Manuscript under review.

Sweeny, K., Reynolds, C.A., Falkenstein, A., Andrews, S.E., & Dooley, M. (2015). *Two definitions of waiting well.* Manuscript under review.

Sweeny, K., & Shepperd, J. A. (2010). The costs of optimism and the benefits of pessimism. *Emotion, 10,* 750-753.

Search for Gluino-Mediated Pair Production of Higgsinos in pp Collisions at 13 TeV in the CMS Detector

Connor Richards, Owen Long

Department of Physics and Astronomy

ABSTRACT

A search for gluino-mediated pair production of Higgsinos, the superpartner of the Higgs boson, is presented using simulated data from proton-proton collisions at a center-of-mass energy of 13 teraelectronvolts (TeV) in the Compact Muon Solenoid (CMS) Experiment at CERN's Large Hadron Collider (LHC). The data sample is normalized to 13 TeV cross-sections and an integrated luminosity of 20 fb^{-1}. This work contributes to the ongoing search for evidence of supersymmetry (SUSY) during Run II of the LHC by studying the expected discovery and exclusion potential of the proposed analysis when run on 13 TeV collider data, which will become available in late 2015. A multidimensional analysis in kinematic variables and a data-driven background estimation method are used here, and our results are reported in terms of two scenarios: (a) an excess of events is observed over the standard model background or (b) no such excess is seen. We find an expected significance of 1.63σ for the case that an excess over standard model processes is observed. In the case where no excess is observed, the expected 95% CL on signal strength (μ^{UL}) and cross-section (σ_{sig}^{UL}) are 0.28 and 9.5 fb, respectively.

Keywords: Supersymmetry (SUSY), Gluino, Higgsino, Lightest Supersymmetric Particle (LSP), Standard Model, Dark Matter, New Physics

AUTHOR

Connor Richards

Department of Physics and Astronomy

Connor Richards is a third year Physics major. He studies physics beyond the standard model at the Large Hadron Collider (LHC). With funding from the Goldwater Scholarship, University of California Regents' Scholarship, UC LEADS Fellowship, and Chancellor's Research Fellowship, he has participated in research and outreach at the European Council for Nuclear Research (CERN) for two years under the guidance of Dr. Owen Long. Currently Vice President of CNAS Science Ambassadors, Richards' passions are research, science outreach, and STEM education. He plans to pursue a Ph.D. in High-Energy Physics and a faculty position.

FACULTY MENTOR

Owen Long

Department of Physics and Astronomy

Professor Long's current research searches for new phenomena from physics beyond the Standard Model of particle physics. In supersymmetric models with R-parity conservation, the lightest supersymmetric particle is stable and may make up the majority of the dark matter in the universe. The experimental signature at the LHC would be events with large missing transverse energy, coming from the lightest supersymmetric particles, which escape undetected. He works on the CMS experiment searching for supersymmetry in events with large missing transverse energy and b-quark jets.

1. INTRODUCTION

The Standard Model of Particle Physics, while a triumph in and of itself, is incomplete; physicists earnestly search for a more complete theory. As such, they often speak of "physics beyond the standard model" or "new physics," which can refer to any number of theories that aim to expand upon the current, experimentally verified knowledge of particle physics. Arguably the most attractive extension to the standard model (SM) is supersymmetry (SUSY).

SUSY could provide answers to some of the biggest questions in physics today. It would explain the hierarchy problem – why the observed mass of the Higgs boson deviates from the natural value by thirteen orders of magnitude [1]. It would allow for Grand Unification [2], meaning that three fundamental interactions – strong, weak, and electromagnetic – could be described as one interaction. Finally, SUSY could also easily explain dark matter, the unobservable mass that comprises 26.8% [3] of the energy in the universe. These are three of the most pressing problems in physics today, and a breakthrough in any one of them would be heralded as a major achievement. Supersymmetry could offer meaningful answers to all three.

In light of this compelling motivation, SUSY research is topical in particle physics [4–6]. A Compact Muon Solenoid (CMS) Collaboration analysis group led by physicists from the University of California, Riverside, has recently published a search for gluino-mediated production of third-generation squarks [4]. This group internally released a second study that searches electroweak production of Higgsinos. In what follows, we present a complementary search for gluino-mediated production of Higgsinos.

As the LHC is not currently in operation, 13 TeV data will not be available until late 2015 at the earliest, so we use Monte Carlo simulations to evaluate the expected discovery and exclusion potential of this analysis when run on CMS data from 13 TeV center-of-mass energy.

2. BACKGROUND

A brief conceptual primer on physics analyses within CMS, written with the aim of familiarizing the uninitiated reader with the relevant physics and techniques, follows. Jargon is avoided where possible, but a basic level of physics knowledge is assumed for brevity.

2.1 CMS Kinematic Variables

In order to move forward, we need to define a small subset of the kinematic variables used in CMS that are especially relevant for this analysis. As we will see, the *transverse momentum* of particles produced in the collision (i.e. the component of a particle's momentum at 90º to the "beam direction") and the *number of quark jets* are especially important for this search.

A *jet* is the signature produced by a quark in the detector. We frequently discuss the *number of jets* in an event, referring to the number of identifiable quarks in the event. We can also measure the transverse momentum of the jets, a vector quantity with magnitude p_T.

We can create two more variables by summing over the transverse momentum of every jet in the event. The *scalar sum of the transverse momenta*, henceforth simply H_T, is the sum of the magnitude of p_T over all jets in the event. With boldface used to denote a vector, and norm(**A**) denoting the Euclidian norm or magnitude of the vector **A**, we have:

$$H_T = \sum_i norm(\boldsymbol{p_T^i})$$

The *negative vector sum of the transverse momenta*, often referred to as the *missing transverse energy*, is the negative of the vector quantity obtained from a sum over $\boldsymbol{p_T}$. $\mathbf{E_T^{MISS}}$ or **MET**, is:

$$MET = -\sum_i \boldsymbol{p_T^i}$$

We often speak of the scalar MET = norm(**MET**) because the direction in the transverse plane itself is not especially instructive in a physics analysis.

2.2 SUSY Signatures in the CMS Detector

The previously defined variables are central to a discussion of SUSY decay signatures. In general, because SUSY particles do not interact with standard model particles – or more colloquially "normal matter", which includes the detector

itself – they are not directly detectable. Instead, we infer their existence based on the particles we can detect. In the decay in question, two of the lightest supersymmetric particles (LSP) are produced and assumed to escape detection. Therefore, we expect to see an "*apparent violation*" of momentum conservation (quantified by the variable MET) due to the SUSY particles escaping detection. In an event where all the particles are observable, we expect zero MET because of momentum conservation. SUSY events, however, will generally have non-zero MET.

Furthermore, in the decay of interest for this paper, we expect a large number of jets. This signal (**Fig. 1**) produces *at least* four jets and, because the Higgs decays most often to two bottom quarks, as many as eight jets through first-order processes. Because of this, the number of jets and H_T are expected to be large relative to standard model processes.
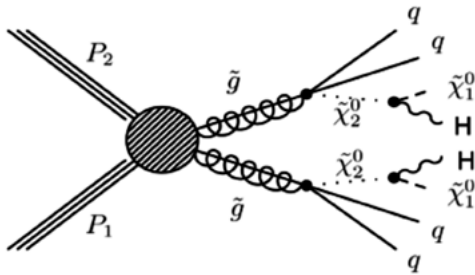
Figure 1: *Feynman diagram for production of two gluinos, which decay to produce four quarks and two $\tilde{\chi}_2^0$ particles. The $\tilde{\chi}_2^0$ then each decay to a Higgs boson and the LSP ($\tilde{\chi}_1^0$). Each Higgs (H) decays, most often to two bottom quarks (not shown in diagram), for a total of eight possible jets.*

2.3 Standard Model Backgrounds

MET, H_T, and the number of jets are powerful variables because we expect them to be large for *signal events* (i.e. events from our decay of interest; see **Fig. 1**), relative to events from standard model processes. These *background events*, SM events that mimic the signature of interest, need to be understood in order to identify and study the signal events.

There are two dominant standard model backgrounds for this decay. The production of a top quark and an anti-top quark, where one of the quarks decays *leptonically* (producing an electron, muon, or tauon), is often referred to as the *top*

quark background. Alternatively, the production of multiple quark jets via the strong interaction is often referred to as the *QCD multijet background* (named for the theory describing the strong interaction, **Q**uantum **C**hromo**d**ynamics). We expect signal and background to peak at different values if our *a priori* assumption, that MET, H_T, and the number of jets are powerful for this analysis, is valid.

2.4 Selection Criteria

Finally, we enforce *selection criteria* on the events in order to preferentially select signal events over background. Events that pass the selection criteria are considered; events that fail are not. In general, selection criteria can be non-trivial combinations of multiple variables, and the methods for choosing a set of selection criteria are numerous. The goal, however, is the same: to maximize the number of signal events and minimize the number of background events.

3. METHODOLOGY

In what follows, we outline the procedure of this search, including determination of selection criteria, background estimation, and interpretation of results in terms of discovery and exclusion. All data analysis was performed using the C++-based ROOT data analysis package.

3.1 Data Samples

Because 13 TeV event data will not be available until late 2015, we explore the anticipated effectiveness of the analysis with Monte Carlo simulations. Because 13 TeV Monte Carlo for this signal is not yet available, we use 8 TeV Monte Carlo renormalized to 13 TeV cross-sections. The three samples, with 13 TeV to 8 TeV cross-section ratios in parentheses, are: semi-leptonic top quark decays (3.3), QCD multijet interaction (6), and signal (26.2).

The signature of this signal is heavily dependent upon the mass of the mediating particle (the gluino) and the particles in the final state. Therefore, because these particles have not yet been observed, we need to assign them masses in order to study the model. Here we consider the case where the gluino is very massive compared to its daughter particles, so we assume a gluino mass of 1350 GeV and an LSP mass

of 100 GeV. This gluino mass is chosen to lie outside the current exclusion limits, so a null result would allow for further exclusion of this model.

3.2 A Priori Selection Criteria

Before fine-tuning the values of the selection criteria, we apply initial selection criteria that are frequently used in SUSY searches to eliminate specific backgrounds. In addition to event cleaning requirements, we require that the events *do not* contain any identified lepton and *do not* contain an isolated, charged track. Both requirements seek to eliminate events with leptons.

The QCD multijet interaction can produce large showers of quarks, and, if the detector mismeasures the momentum of one or more jets, it can result in a non-zero MET vector. When this happens, the MET vector often lies along the same direction as a jet, so we further require that the angle between each jet and the MET vector, defined as Δø, be *greater* than 0.5 radians.

Requirements on the presence of leptons and charged tracks and on Δø seek to eliminate the top quark and QCD multijet backgrounds, respectively, without reducing the signal.

3.3 Multidimensional Scan in MET, HT, Number of Jets, and Number of Bottom Quark Jets

In order to optimize the selection criteria and discriminate against background, we construct a multidimensional optimization scan in four variables: MET, H_T, number of jets, and number of bottom quark jets to simultaneously maximize Q. We define the metric Q as:

$$Q \equiv 2\sqrt{N_{sig} + N_{bg}} - 2\sqrt{N_{bg}}$$

where N_{sig} and N_{bg} are the number of signal and background events, respectively. This gives an estimate of the expected significance (in standard deviations from the null hypothesis) for a given selection criteria, so larger values generally indicate better selection criteria.

Because the signal peaks at high values of the kinematic variables relative to the backgrounds, as shown for H_T in **Fig. 2**, Q is large when we require that these variables are large. As a result, we place stringent requirements on the value of MET, H_T, and the number of jets. For reasons that will be explained in the next section, we require MET > 300 GeV, H_T > 1600 GeV, number of jets ≥ 6, and at least one (medium working point) bottom quark jet [7] here.
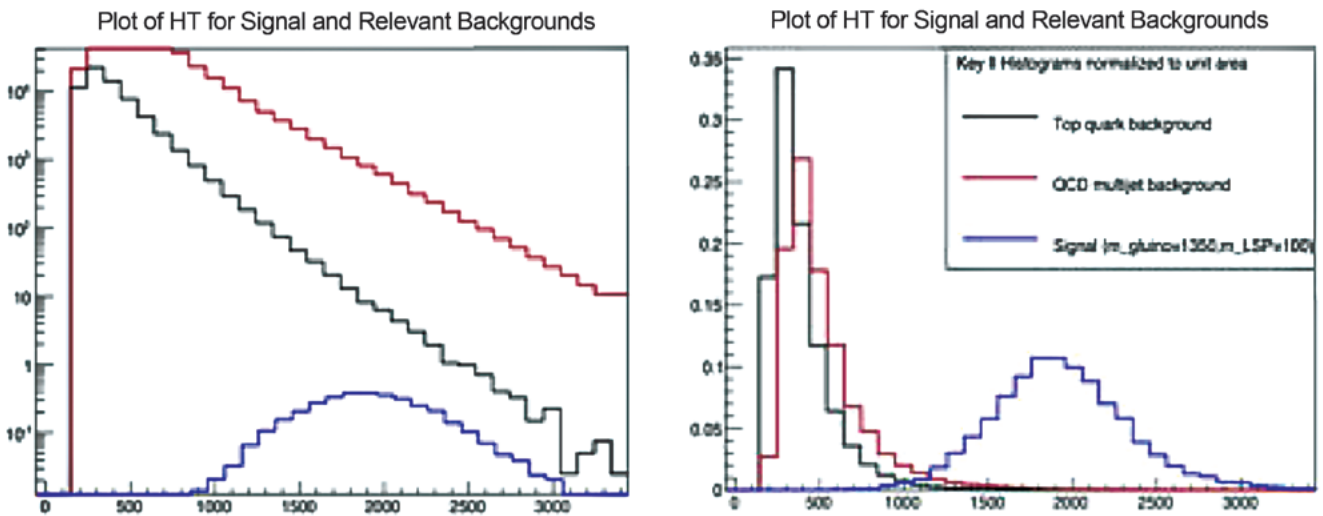
Figure 2: Histogram of H_T (x-axis) for the top quark background (black line), QCD multijet background (red line), and the signal (blue line). (2a, left) Distributions are shown on logarithmic scale and normalized to number of expected events to show the order(s)-of-magnitude difference between signal and background, roughly 10^3 more background events than signal, even at large H_T. (2b, right) Distributions are shown on a linear scale and normalized to unit area to show the shape difference between signal and backgrounds. Note: backgrounds are not stacked.

3.4 ABCD Background Estimation

In order to create a data-driven estimate of the relevant backgrounds, we create exclusive bins, known to be either *background-dominated* or *signal rich*, and we use the number of events in these bins to arrive at a blind, data-driven estimate for the number of expected events in our search region. In order to do this, we need two variables that are uncorrelated.

To estimate the top quark background, we can use the number of leptons and H_T to create these exclusive bins (labeled A, B, C, and D). We first apply all the aforementioned selection criteria, with the exception of requirements on the number of leptons and the value of H_T. We define a single lepton *control region*, where we require exactly one lepton, and a *search region* where we require exactly zero leptons. Furthermore, **Fig. 2a** shows that our signal peaks at higher values of H_T, so low values ($H_T < 1600$ GeV) are *background dominated* and high values ($H_T > 1600$ GeV) are *signal rich*. Using these, we can define four regions, as follows: D (*background dominated control region*, 1 lepton, $H_T < 1600$), B (*background dominated search region*, 0 leptons, $H_T < 1600$), C (*signal rich control region*, 1 lepton, $H_T > 1600$), and A (*signal rich search region*, 0 leptons, $H_T > 1600$). We denote the number of events in region X as N_X.

By assuming that the ratio of the number of events in these regions, namely $N_B:N_D$ and $N_A:N_C$, are the same, we can estimate N_A by measuring N_B, N_C, and N_D. For the selection chosen in §3.3 applied on a 20 fb^{-1} sample of 13 TeV data, we find $N_B = 117.0$, $N_C = 0.248$, $N_D = 12.84$, giving an estimate of $N_A = 2.27^{+4.59 \text{ stat}}_{-2.27 \text{ stat}}$ events from this background where the uncertainties given are the statistical uncertainties resulting from the uncertainties on the counting statistics of N_B, N_C, and N_D. The expected value of N_A from this background, calculated from the Monte Carlo, is 2.8, so we say that the ABCD method *closes* to within roughly 20%, meaning our calculated value (2.27) is in agreement with the actual value (2.8). Another *closure test* is to verify that $N_B/N_D = 9.2 \approx N_A/N_C = 11.2$, which also gives agreement to roughly 20%. Based upon these closure tests, we say that the ABCD method closes and is therefore valid.

3.4.1 Brief Note on ABCD for QCD Multijet Background

We do not include calculation of the ABCD background estimate from the QCD multijet background here because constructing a proper ABCD is non-trivially more difficult than for the top quark background. Instead, we make use of selection criteria that effectively eliminates the contribution from the QCD multijet. For our selection, we expect 0.1 events from the QCD multijet compared to the single- and double-digit counts from the top quark background and signal, so it is negligible to first-order and can safely be ignored for the chosen selection.

4. RESULTS

For the selection criteria discussed in *§3.2* and *§3.4*, we expect $N_A^{\text{sig}} = 20.06^{+4.48 \text{ stat}}_{-4.48 \text{ stat}}$ signal events based upon the Monte Carlo (with a *signal efficiency*, the fraction of signal events passing the selection, $\varepsilon_{\text{sig}} = 0.0295$). From our ABCD estimate for the top quark background, we expect $N_A^{\text{bg}} = 2.27^{+4.59 \text{ stat}}_{-2.27 \text{ stat}}$ background events for this selection. In what follows, we construct a likelihood function and perform a profile likelihood scan in order to quantify our results in terms of the *signal strength* of the model (defined to be 1 if the signal exists, and 0 otherwise).

4.1 Profile Likelihood Scan

We first define a likelihood function (*L*) as the product of the individual probability density functions for the counts in bins A, B, C, and D, which follow Poisson distributions. A more complete description can be found elsewhere [8]. However, since N_B and N_D are both large (N_B, $N_D > 5$), we can approximate their ratio, $N_B/N_D = R$, as a Gaussian. This simplification means the free parameters of our likelihood function are simply: R, the statistical uncertainty on R (σ_R), the number of signal events in A (N_A^{sig}), the number of background events in A (N_A^{bg}), and the signal strength (μ). Given the values of R, σ_R, N_A^{sig}, and N_A^{bg}, all of which are known, we can evaluate the expected significance and the expected upper-limit on the signal strength.

Fig. 3 gives the results of this scan for the expected significance and signal strength upper-limit, respectively. **Fig. 3a** shows the expected significance of observing

$N_A^{sig} + N_A^{bg}$ total events where the null hypothesis is that the observed number of events are entirely from the SM backgrounds. **Fig. 3b** shows the 95% CL upper-limit on the signal strength of this process assuming we observe only N_A^{bg} events (i.e. no excess over the SM background). Therefore, for a data sample of 20 fb^{-1} of 13 TeV data, we find an expected significance of 1.63σ and a 95% confidence level upper-limit on signal strength of $\mu^{UL} = 0.28$ for the cases that there is and is not an excess over the SM backgrounds, respectively. Since a significance of 3σ is needed to claim evidence, we do not expect to find "evidence" of a SUSY signature.

4.2 Exclusion Capabilities

Recall that $\mu = 1$ if the signal exists, so $\mu^{UL} = 0.28$ means we expect to be able to set an aggressive limit on the cross-section of this process if no excess is seen. The upper-limit on the cross-section of a process (also denoted σ) is simply the nominal cross-section, σ_{sig}^{NOM}, multiplied by μ^{UL}. For this signal, the nominal cross section σ_{sig}^{NOM} is 0.034pb, or 34 fb, at 13TeV. This means that the expected 95% CL upper-limit on the production cross-section will be:

$$\sigma_{sig}^{UL} = \sigma_{sig}^{NOM} \times \mu^{UL} = 0.034\ pb \times 0.28 = 0.0095\ pb = 9.5\ fb$$

To put this number into perspective, the production cross-section for the standard model Higgs boson at 8 TeV – the elusive scalar boson whose discovery at CERN in 2012 won the Nobel Prize the same year – is roughly $\sigma_h^{8\ TeV} \approx 20$ pb [9]. This is 10^3 times larger than the $\overline{\sigma_{sig}^{UL}}$, and the Higgs was "elusive" because of its relatively small cross-section. This means that $\overline{\sigma_{sig}^{UL}}$, the upper limit on the chance of this decay occurring, would be 3 orders-of-magnitude smaller than the chance of producing a Higgs boson at 8 TeV, which is already a small number.

5. DISCUSSION

5.1 Discrepancy between Q and Calculated Significance

In *§3.3* we introduced the metric Q as an estimate for the significance of a given selection. We found a significance of 1.63 σ, but for this selection, Q > 6. This discrepancy is at odds with the statement that Q is a good estimator for significance, and the reason for this apparent contradiction – which is not obvious – lies in the number of background events.

We are encountering the problem of "low statistics" in our background, namely that the relevant backgrounds are either rare or poorly understood in the region(s) of interest. As sometimes happens in SUSY searches, the hard kinematic requirements necessary to pick-out the signal sometimes kill the statistical ability of the analysis to differentiate an excess of signal from a background fluctuation. In this
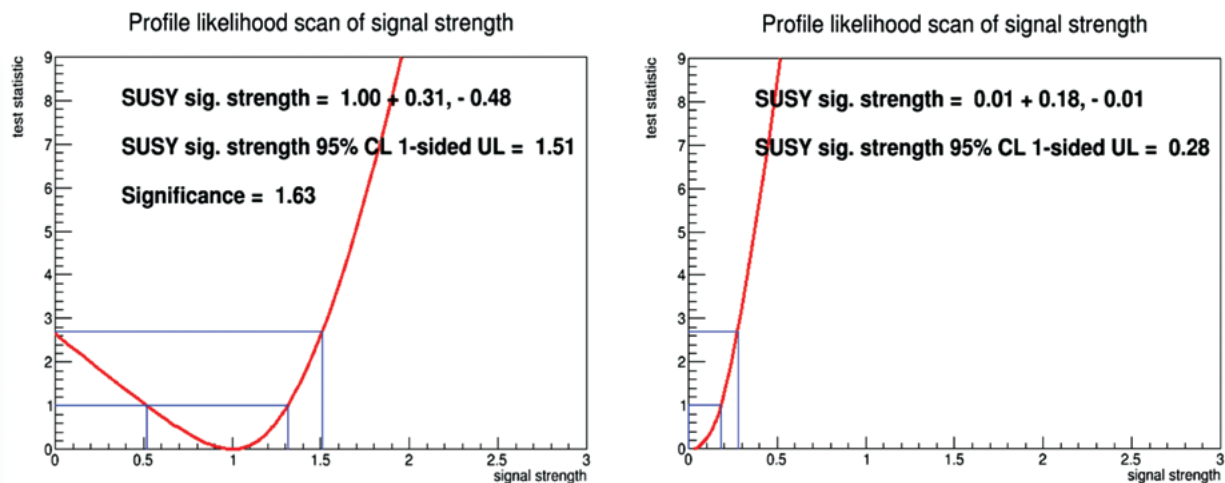
Figure 3: (3a, left) Likelihood, as a function of signal strength, of observing $N_A^{sig} + N_A^{bg}$ events. Reported significance (1.63) is the excess of observed events, measured in number of standard deviations, for the background-only (μ = 0) hypothesis for 20 fb^{-1} of 13 TeV data. (3b, right) Likelihood, as a function of signal strength, of observing N_A^{bg} events. Reported value of signal strength (μ^{UL} = 0.28) is 95% confidence level upper-limit on signal strength if no excess over the standard model backgrounds is observed for 20 fb^{-1} of 13 TeV data.

case, the extremely low number of expected events in the C region (0.248) cripples the statistical power of the analysis, as this propagates into the statistical uncertainty on the ABCD estimate of N_A^{bg}. Were N_C larger (~10), meaning the background was better understood, we would expect a higher significance consistent with $Q \approx 6$.

5.2 Implications of This Study for Run II of the LHC

The search for supersymmetry has been proceeding in earnest at CERN ever since the LHC turned on in 2009 [10]. These efforts were redoubled following the Nobel Prize-winning discovery of the Higgs boson, another main goal of the LHC's physics program, in 2012 [11]. The hierarchy problem, Grand Unification, and the identity of dark matter are three of the most important questions in physics today, each one a Nobel-worthy problem. The compelling motivation behind SUSY lies in the elegance with which it would explain all three.

The purpose of this study was to evaluate the effectiveness of a dedicated analysis searching for Higgsinos produced via the strong interaction. With the LHC's increase in energy to 13 TeV during Run II, which starts later this year, we have the opportunity to probe even higher energies (and therefore, based on Einstein's $E = mc^2$, masses) in search of new physics.
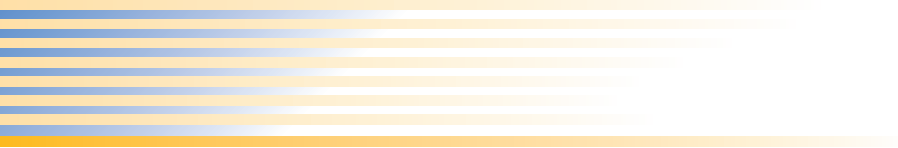
We have shown here that an analysis using hard requirements on MET, H_T, number of jets, and number of bottom quark jets will set an aggressive upper-limit on the cross section ($\sigma_{sig}^{UL} = 9.5$ fb) if no excess over the SM background is seen. We further note that a more sophisticated study is needed to assess the statistical significance if an excess *is* seen.

ACKNOWLEDGEMENTS

REFERENCES

[1] S. Dimopoulos, S. Raby, and F. Wilczek, "Supersymmetry and the scale of unification", *Phys. Rev. D*, **24** (1981) 1682, doi: 10.1103/ PhysRevLett.112.068103

[2] L. E. Ibañez, "Grand unification with local supersymmetry", *Nuclear Physics B*, **218** (1983) 514, doi: http://dx.doi.org/10.1016/0550-3213(83)90378-4

[3] The Planck Collaboration, "Planck 2013 Results. I. Overview of products and scientific results", 2013, arXiv:1303.5062

[4] The CMS Collaboration, "Search for gluino mediated bottom- and top-squark production in multijet final states in pp collisions at 8 TeV", *Phys. Lett. B*, **725** (2013) 243, doi: 10.1016/j.physletb.2013.06.058

[5] The CMS Collaboration, "Inclusive search for squarks and gluinos in pp collisions at sqrt(s) = 7 TeV", *Phys. Rev. D*, **85** (2012), 012004, doi: 10.1103/ PhysRevD.85.012004

[6] The ATLAS Collaboration, "Search for squarks and gluinos with the ATLAS detector in final states with jets and missing transverse momentum using 4.7 fb^{-1} of sqrt(s) = 7 TeV proton-proton collision data", *Phys. Rev. D*, **87** (2013) 012008, doi: 10.1103/ PhysRevD.87.012008

[7] The CMS Collaboration, "Identification of b-quark jets with the CMS Experiment", *JINST*, **8** (2013) P04013, doi: 10.1088/1748-0221/8/04/P04013

[8] ATLAS, CMS Collaboration, "Procedure for the LHC Higgs boson search combination in summer 2011", Technical Report ATL-PHYS-PUB-2011-011, CMS NOTE-2011/005, CERN, Geneva, (Aug, 2011)

[9] D. de Florian, et. al. "Higgs production at the LHC: updated cross sections at √s = 8 TeV", *Phys. Let. B*, **718** (2012) 117, doi:10.1016/j.physletb.2012.10.019

[10] R. Kitano and Y. Nomura, "Supersymmetry, naturalness, and signatures at the CERN LHC", *Phys. Rev. D*, **73** (2006) P095004, doi: 10.1103/ PhysRevD.73.095004

[11] H. Baer, V. Barger, and A. Mustafayev, "Implications of a 125 GeV Higgs scalar for the LHC supersymmetry and neutralino dark matter searches", *Phys. Rev. D*, **85** (2012) P075010, doi: http://dx.doi.org/10.1103/ PhysRevD.85.075010

Laboratory Fire Behavior Measurements of Chaparral Crown Fire

Chirawat Sanpakit[1], Sunday Omodan[1], Dr. David Weise[2], Dr. Marko Princevac[1]

[1]Department of Mechanical Engineering, UC Riverside
[2]USDA Forest Service, Pacific Southwest Research Station

ABSTRACT

In 2013, there was an estimated 9,900 wildland fires that claimed more than 577,000 acres of land. That same year, about 542 prescribed fires were used to treat 48,554 acres by several agencies in California. Being able to understand fires using laboratory models can better prepare individuals to combat or use fires. Our research focused on chaparral crown fires. Chaparral is a shrub community that blankets 5% of California land. As a result, it becomes key fuel sources for wildfires. By using chaparral to model crown fires, our goal is to develop a model that can be deployed for evacuation planning or firefighting in the event of these fires. Laboratory experiments were conducted at the USDA Forest Service Pacific Southwest Research Station. We utilized a wind tunnel equipped with cameras for visualization, arrays of thermocouples, and an in-house developed MATLAB script to analyze experiments. By controlling wind tunnel velocity, fuel moisture content and fuel geometry, we have quantified the fires by their flame heights, flame velocities and fuel consumption rates. Experiments were conducted inside the wind tunnel, with a raised platform for modeling crown fires. Results showed that wind velocity significantly enhances fire intensity and creates a far more destructive flame relative to one without wind. Also, depending on other variables, torching, incomplete burns, or spotting were observed in our experiments. Finally, results were used to validate a Computational Fluid Dynamics program that simulates fires.

Keywords: Wildfire; Chaparral; Fire Dynamic Simulator; Computational Fluid Dynamic Model; Wind Tunnel; Crown Fire; Chamise; Experimental Modeling

FACULTY MENTOR

Marko Princevac

Department of Mechanical Engineering

Doctor Princevac is interested in fundamental and applied fluid mechanic research – in particular, the application of fundamental turbulence concepts to studies in environmental flows. During his graduate studies and a short post-doctoral period afterward, he gained a strong background in laboratory and field experimental work. This helped him identify some physical phenomena and build simple physical laboratory models that can successfully explain complex field observations or a part thereof. He also has experience in developing idealized theoretical models to explain fluid dynamic processes.

AUTHOR

Chirawat Sanpakit

Department of Mechanical Engineering

Chirawat Sanpakit is a second year Honors student majoring in Mechanical Engineering. As an HSI recipient, he conducts research in Dr. Marko Princevac's Laboratory for Environmental Flow Modeling. Working closely under Christian Bartolome (Ph.D.), undergraduate students, and the team from the USDA Pacific Southwest Research Station, he systematically explored mechanisms of Chaparral Wildfire in order to develop plans to combat or utilize them. He will serve as the 2015-2016 ASME Vice President and he hopes to pursue his Ph.D. in Aerospace Engineering or Mechanical Engineering.

INTRODUCTION

Wildland fires pose both serious economic and safety problems. Having the ability to predict the potential behavior and effects of wildland fires is an essential task in fire management (Scott et al., 2005). Wildfires are complex phenomena and most models used in the U.S. operationally (see review by Engstrom et al., 2010) are based on the empirical correlations developed by Byram (1959), Fosberg and Deeming (1971), Rothermel (1972), Van Wagner (1973) and Albini (1976). Many of the models, such as FARSITE (Finney, 1998) and BEHAVE (Andrews, 1986), are suitable for use by fire managers. Despite their usefulness, the models are limited to surface fuels in rangelands and forests. Moreover, prediction of spread rates and fire intensity for live vegetation are not very accurate (Engstrom et al., 2010). Thus, to improve these models, numerous studies are being conducted on wildland fires. However, very little research has been done on chaparral crown fires with live vegetation. To address this disparity, an experimental design was developed to study crown fires.

CONCEPTUAL FRAMEWORK

Our research focused specifically on the surface-crown interaction of wildland fires. Crown fire is a type of wildland fire that spreads faster than surface fires and occurs in elevated foliage (Rothermel, 1983). To improve current models of wildfires and their transition to tree crowns, fire experiments were conducted in a wind tunnel. Each experiment focused on understanding the behavior of chaparral crown fires, particularly the ignition, mechanism of flame propagation, spreading, flame front velocities, and fuel consumption rates. A Computational Fluid Dynamics (CFD) model was also deployed to predict and observe fire behavior. The Fire Dynamics Simulator (FDS) (McGrattan et al., 2013) was selected as the CFD model since it is readily available and has been modified for use in wildland fuel beds (Mell et al., 2009). Although computationally slower when compared to empirical models, CFD modeling is generally more accurate.

METHODOLOGY

All experiments were conducted inside of a wind tunnel (Figure 1) at the USDA Forest Service, Pacific Southwest

Figure 1: *Live burn being conducted on chamise (Upper platform) by ignition of excelsior (lower platform) inside of the wind tunnel.*

Research Station (PSWRS). Once activated, a large fan spins at 40 Hz, simulating wind moving at 1m/s on the flames. Each test utilized load cells, MATLAB, thermocouples, scales, wet-bulb hygrometer, and video analysis for data gathering. To model surface fuel and crown fuel, 500 grams of excelsior (shredded wood) and 2000 grams of chamise, a common chaparral shrub were used, respectively. The chamise was harvested locally from the North Mountain Experimental Area to minimize moisture loss. Wind velocity, height of the crown fuel, presence of surface fuel, and fuel moisture content were changed between experimental runs. The gathered data was used to analyze the resulting flame heights, flame front propagation velocities, and fuel consumption rates.

Experimental Classifications

The experiments were classified into six specific classes based on the presence of the excelsior surface fuel bed, the height to the base of the crown fuel bed, and wind velocity. Table 1 presents what variables were involved and what parameters were kept constant for each class (A-F).

Table 1: *Organization of different classes of experiments.*

Classification	Surface Fuel Bed	Wind	Crown Height
A	Absent	No wind	60 or 70 cm
B	Absent	1 ms⁻¹	60 or 70 cm
C	Present	No wind	60 cm
D	Present	No wind	70 cm
E	Present	1 ms⁻¹	60 cm
F	Present	1 ms⁻¹	70 cm

Setup of the Experiments

A wire mesh basket was raised to the specified height to model the crown fuel. Five equally spaced thermocouples were placed in the crown fuel to measure the temperature and, indirectly, the crown fuel flame spread rate. The 2000 g of chamise were evenly distributed in the wire basket. The surface fuel bed was laced with ten, equally spaced, thermocouples that were also used to measure the temperature and surface flame spread. The 500 g of excelsior was evenly spread across this surface. Load cells were placed under the surface fuel bed to measure mass loss rate. Before the start of each trial, samples of chamise were collected to determine the fuel moisture content. Finally, each experiment was recorded using a video camera. The setup is depicted in Figure 2.
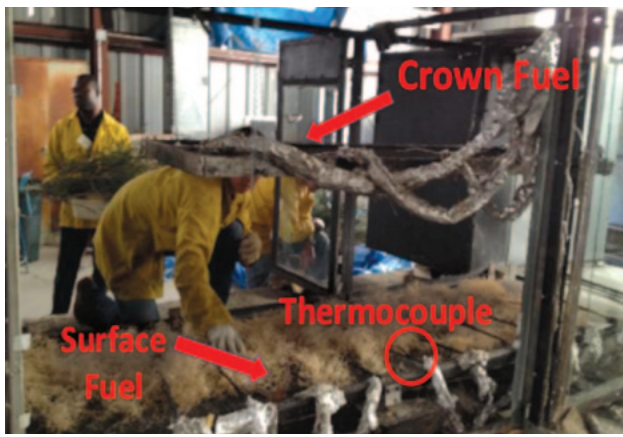
Figure 2: *Setting up of live experiments. Excelsior is uniformly spread on surface.*

For experimental classes C-F, the surface fuel was ignited by a hand-held lighter along a line of ethyl alcohol, perpendicular to the wind. For experiments A and B, the crown was directly ignited.

Fire Dynamic Simulator

The Fire Dynamics Simulator (FDS) is a CFD model that solves a numerically discretized form of the Navier-Stokes equation for low speed, thermally-driven flow and/or scalar transport in fire structures (McGrattan et al., 2013). The equation is solved on a user-specified 3-D mesh (grid) and the model becomes more accurate, though more computationally intensive, as the distance between grid points is decreased. The model was formulated to simulate fire in rectangular buildings so rectilinear grids are the

simplest numerical grids applicable. Because FDS is a large eddy simulation (LES) model, uniform mesh spacing is preferred. Once the mesh is established, a rectangular object that defines the geometry is easily created. The model's governing equations of the conservation of mass, momentum and energy, are approximated using second-order finite differences on a collection of uniformly spaced three-dimensional grids (McGrattan et al., 2013).

Combustion and Radiation Model in FDS

To be able to simplify and make the fire simulation tractable, the FDS model assumed that the number of fuels was limited to one, the number of reactions was just one or two at most, the incoming air stream was left open due to the possibility of the fire extinguishing from a lack of oxygen, and that the air was neither fuel or product and was treated as a single gas species. FDS uses a modified finite volume method to calculate radiative fluxes during simulations. This method is derived from the Radiative Transport Equation (RTE) for non-scattering grey gas (Hume, 2003). FDS assigns the temperature generated from a flame sheet to adjacent cells. This can greatly impact calculated radiation because of radiation's large dependence on temperature.

Deployment and Output of FDS

The user builds an input file that details information such as grid size, geometry of the scenario being modeled, or boundary conditions. For visualization, the output is shown in Smokeview (Figure 3), a packaged add-on in FDS. Quantitative data display uses techniques such as 2D and 3D contouring. A realistic display is used to present the data in a form that would actually appear in real life (Fourney, 2013).
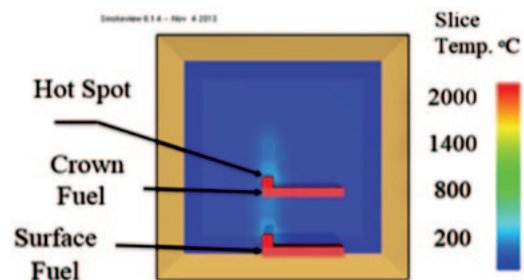
Figure 3: *2D viewpoint of a simulation outputted in Smokeview. Hot Spot is introduced in a way such that the buoyant flow of hot air is induced. This effect represents a firebrand in the live experimental setups.*

RESULTS

The crown fire experiments were repeated at least 9 times per class in order to ensure the repeatability and accuracy of results. For each experiment, we determined the flame front velocity, flame height, and heat production.

Flame Front Velocity

Flame propagation velocity was obtained from the analysis of thermocouple data after several experimental trials (Figure 4). The peak temperatures of each thermocouple were determined to indicate the flame arrival, and the thermocouple distance was then divided by time between temperature peaks to obtain the desired velocity. Note that 4 out of the 8 crowns in class C, as well as 2 of the 8 crowns in class D, failed to ignite despite the surface flames. Similarly, no experiments in class A were able to burn to completion.

Flame Heights

All heights shown in Figure 5 are averages of still images that were captured from video analysis of experiments. However, crown flame height exceeded the frame of the video and could not be calculated in class C-F. Flame height and length are used interchangeably in literature, but for the purpose of this research, the vertical distance to the flame tip was referred to as the flame height (Alexander and Cruz, 2012).
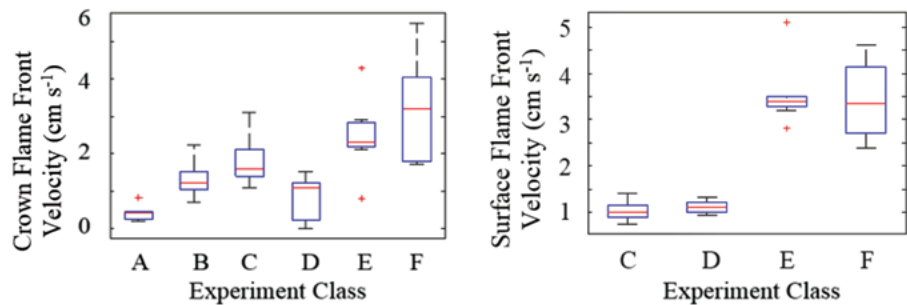
Figure 4: Calculated Flame Front Velocities. (a) Velocities for Crown fuel. (b) Velocities for Surface fuel.
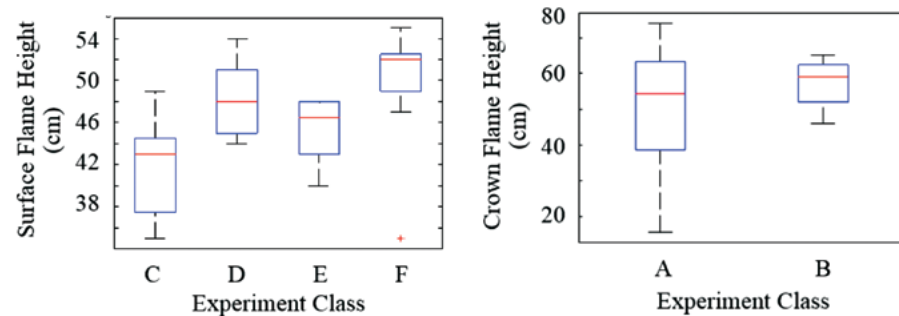
Figure 5: Flame heights of live experiments. (a) Height of Surface fuel flames from video analysis of live experiments. (b) Flame heights for the crown fuel bed. Class C-F experiments exceeded frame of video and thus could not be calculated.
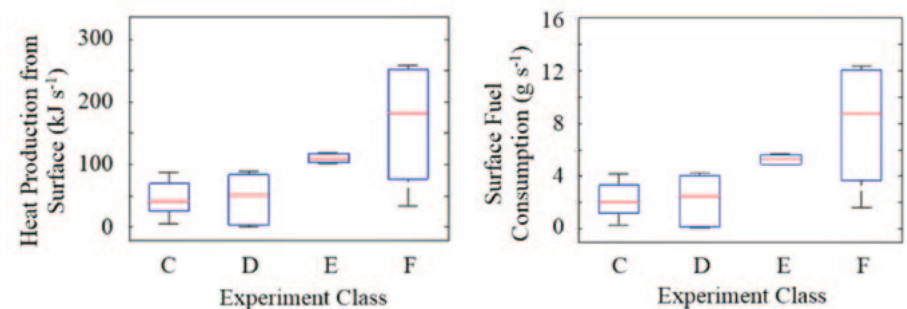
Figure 6: Vegetation burn off rate. (a) Calculated heat production rate of Surface fuel. (b) Mass consumption rate of Surface fuel from load cell data.

Fuel Consumption

The burning rate of the surface fuel was investigated (Figure 6) and can be effectively expressed as $q = H\,dm/dt$, where q is the energy released, dm/dt is the mass loss rate per unit time (fuel consumption rate), and H is the heat value of the material being burned.

Results of Fire Dynamic Simulator

Five classes of simulations were run for 8-40 seconds of simulation time. Surface fuel bed depth and height between fuel beds were kept constant at .2 and .7 meters, respectively. Table 2 shows the classes of FDS simulations and their respective parameters. Table 3 shows values of the simulation parameters as well as resulting burnout times.

DISCUSSION

Experiments were conducted over several classes. Each class depicted a change in either crown height, presence of surface fuel, wind, fuel moisture content, or any combination of these parameters. Ignition temperature is the critical fuel temperature at which flaming combustion initiates (Saito, 2001; Williams, 1982). Thermocouple data showed that hot gases from the surface fuel provided convective heating and raised the chamise's temperatures to 564K, above the reported ignition temperature of 523K for chamise (Babrauskas, 2003).

The largest contributing factor to the flame's propagation speed, consumption rate, and height was the addition of wind. The fuel consumption rate, crown speed, and height all increased, as shown in figure 4, 5 and 6, due to the addition of wind. The wind caused the flame to bend over, which allowed the fuel to be preheated more efficiently. This led to an increase in the measured parameters when compared to no wind conditions.

Table 2: Classes of FDS simulation and their parameters.

Class	Surface Fuel	Crown Fuel	Hotspot on Surface	Hotspot on Crown
1	Absent	Present	Present	Present
2	Present	Present	Present	Absent
3	Present	Present	Present	Present
4	Present	Absent	Present	Absent
5	Present	Present	Present	Absent

Table 3: Parameters of various simulations within each class and burnout time results.

Simulation #	Class	Bulk Density (kg/m^3)	Hot Spot (deg. C)	Burnout Time (sec)
1,2,3,4	1	20,15,10,5	5000	8,7.99,6.95,4.85
1,2,3,4	2	20,15,10,5	5000	7.99,7.5,5.7,4.46
1,2,3,4	3	20,15,10,5	5000	7.6,6.32,5.51,4
1,2,3,4	4	20,15,10,5	5000	7.98,7.78,6.46,5.08
1,2,3,4	5	15	5000,6000,7000,8000	8.65,7.14,6.46,5.24

CLASSIFICATION A-F

The class A setup produced an extremely slow moving flame that was never able to completely consume the crown. The class B setup (Figure 7) included wind which caused the flame tilt. The flame front velocity increased approximately 3 times from .42 cm s^{-1} to 1.30 cm s^{-1} when compared to class A and in 78% of the cases, the crown was completely consumed. Heat production of class B was estimated to be 235.5 kJ s^{-1}. Class C experiments (Figure 8) studied the interactions between surface fuel and crown fuel at 60 cm crown height without the addition of wind. A more columnar flame was observed and results showed that the surface flame did in fact help with the propagation of crown flames. Here, there were 78% of cases with a successful crown ignition due to surface flames and 44% of the cases had full crown consumption.

Figure 7: Class B Experiment. Flame velocity and fuel consumption rate rise significantly due to added wind.

Figure 8: Class C Experiment. The propagation of crown flame is furthered by addition of surface fuel.

Figure 9: Class E Experiment. Flame velocity and overall intensity is substantially higher due to addition of surface fuel and wind parameters.

Crown heat production was found to be 412.0 kJ s⁻¹. Class D was similar to class C, except for the fact that the crown height was raised to 70 cm. This class exhibited torching at the mid-section, ignition near the middle of the crown bed, and backfires. Class D had a 75% crown ignition rate and 50% of the cases had full crown consumption. Moreover, the crown flame velocity was considerably less at 1.14 cm s⁻¹ for class D versus 1.82 cm s⁻¹ for class C. Here, the additional height seems to create difficulty for crown flame ignition to occur and also led to the slowdown of the crown flames themselves. Crown heat production was approximately the same as class C, producing 348.8 kJ s⁻¹. Class E experiments (Figure 9) were setup to investigate the interactions of surface and crown fuels at 60 cm crown height with the addition of wind. Both surface flame velocity and crown velocity increased significantly when compared to prior experiments, averaging at 2.47 cm s⁻¹ for the crown velocity. Also, 100% of the experiments showed crown ignition due to surface flames, furthering the idea that wind was a major contributing factor to the flame's overall properties. Class F experiments are identical to class E except for the crown height, which was 70 cm. Despite the difference in height, class E and F experiments were almost identical in terms of how the flames moved. The surface flame had no trouble igniting the crown, resulting in an 89% ignition rate. The crown was completely consumed 78% of the time and 89% of the time for class E and F, respectively. A considerably higher crown flame velocity was observed than class E, averaging at 3.16 cm s⁻¹. Finally, heat production between class E and F were fairly close to each other, averaging 575.5 kJ s⁻¹ for E versus 616.8 kJ s⁻¹ for F. Note that due to a lack of load cells, crown fuel consumption rate and heat production were not found in the same way as the surface fuel. Instead, a mass loss rate was determined by assuming the 2000 g of chamise burned evenly over the time it took the flames to entirely consume the fuel. Resulting heat production was later calculated and averaged. Class A was not available because 0 cases resulted in full crown fuel consumption. Data and video analysis supported observations and all results are summarized in Table 4.

Evaluation of Fire Dynamic Simulator

The results from Tables 2 and 3 show that in FDS modeling, the burn rate of solid fuels depended on flame temperature, bulk density, fuel thickness, and height between crown and surface fuel. A high hot spot temperature led to a faster burning rate, such as 8000K leading to a burnout rate of 5.24 seconds versus 5000K leading to a burnout rate of 8.65 seconds. Also, burning rate was inversely proportional to the bulk density of the solid fuel. A bulk density of 20 kg m⁻³ yielded a burnout time of 8 seconds versus 5 kg m⁻³ which yielded a burnout time of 4.85 seconds. The results in Table 3 also show that burnout times for simulations containing surface and crown fuel were shorter than simulations with only crown or only surface fuel. Finally, the burnout time of reacting solid fuel was automatically calculated by FDS as $t = (\rho\delta\Delta H)/q''$ where δ is the fuel layer thickness, ΔH is the heat of combustion, ρ is material density, and q'' is the heat released.

CONCLUSION

The laboratory experiments conducted on live chaparral crown fuel have shown that several variables can aid in the propagation of flames, which includes the addition of wind, decreased distance from surface flame, and presence of surface fuel. The CFD model deployed has also confirmed some of what was seen in the laboratory experiments, such as the shorter burnout times when both surface and crown fuel were present. The results gathered can be used to improve current models on wildland fires, which could lead to saving lives and property, especially in chaparral areas of California. Future work needs to be done on developing an experimental setup that can more successfully capture the crown flame heights as well as solving the problem of

Table 4: *Summary of results from surface fire/crown fire transition experiments.*

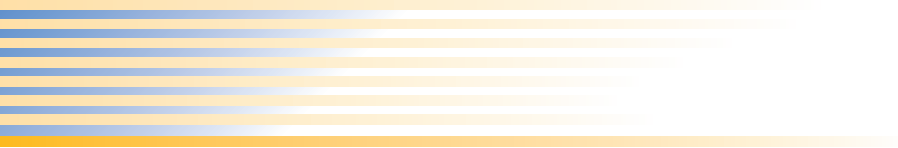| Class	Crown Ignition Rate (%)	Full Crown Consumption Rate (%)	Crown Flame Front Velocity (cm s⁻¹)	Heat Production (kJ s⁻¹)
A	No Surface Fuel	0%	.42	N/A
B	No Surface Fuel	78%	1.30	235.5
C	78%	44%	1.82	412.0
D	75%	50%	1.14	348.8
E	100%	78%	2.47	575.5
F	89%	89%	3.16	616.8

numerical instability that sometimes occurred in FDS. The other problem was the inability for FDS to recognize two fuels of different materials in the same simulation. Future development could yield a solution to this issue.

ACKNOWLEDGEMENTS

REFERENCES

Albini, F.A. "Estimating Wildfire Behavior and Effects." *USDA Forest Service General Technical Report INT-30*, 1976.

Alexander, M.E., and M.G. Cruz. "Crown Fire Dynamics in Conifer Forests in Synthesis of Knowledge of Extreme Fire Behavior for Fire Managers." *USDA Forest Service General Technical Report PNWGTR-854* 1, pp. 107-42, 2012.

Andrews, P.L. "BEHAVE: Fire Behavior Prediction and Fuel Modeling System, BURN - Subsystem, Part 1." *USDA Forest Service General Technical Report INT-194*, 1986.

Babrauskas, V. *Common Solids, Ignition Handbook*. Issaquah, WA: Fire Science Publishers, 2003.

Byram, G.M., and K.P. Davis. *Combustion of Forest Fuels in Forest Fire: Control and Use*. NY: McGraw-Hill, 1959.

Engstrom, D., J.K Butler, L.L. Baxter, T.H. Fletcher, and D.R. Weise. "Ignition Behavior of Live California Chaparral Leaves." *Combustion Science and Technology* 176, no. 9, pp. 1577-591, 2010.

FDS-SMV Official Website. July 31, 2009. Accessed March 14, 2015. http://www.fire.nist.gov/fds.

Finney, M.A. "FARSITE: Fire Area Simulator-model Development and Evaluation." *US Forest Service RMRS – RP – Research Papers*, March 1998.

Fosberg, M., and J.E. Deeming. "Derivation of the 1-hour and 10-hour Time Lag, Fuel Moisture Calculations for Fire-Danger Rating." *US Forest Service RM - RN - Research Notes*, pp. 8, 1971.

Fourney, G. "Smokeview (Volume 6) A Tool for Visualizing Fire Dynamics Simulation Data." *NIST Special Publication 1017-2* 2, 2013.

Hume, B. "Water Mist Suppression in Conjunction with Displacement Ventilation." *Fire Engineering Research Report, University of Canterbury*, 2003.

McGrattan, K., et al. "Fire Dynamics Simulator (Version 6) Technical Reference Guide Volume 1: Mathematical Model." *NIST Special Publication 1018-6* 6, 2013.

Mell, W.; Maranghides, A.; McDermott, R.; Manzello, S. L., 2009: Numerical simulation and experiments of burning douglas fir trees. *Combustion and Flame*, 156, 2023–2041.

Rothermel, R.C. "How to Predict the Spread and Intensity of Forest and Range Fires." *USDA Forest Service General Technical Report INT-143*, 1986.

Saito, K. "Forest Fires: Behavior and Ecological Effects." *ELSEVIER*, 2001.

Scott, J.H., and R.E. Burgan. "Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model." *US Forest Service RMRS - GTR - General Technical Reports*, 2005.

Van Wagner, C.E. "Height of Crown Scorch in Forest Fires." *Canadian Journal of Forest Research*, pp. 373-78, 1973.

Williams, F. "Urban and Wildland Fire Phenomenology." *Progress in Energy and Combustion Science* 8, no. 4, pp. 317, 1982.

Pronoun Usage By Doctors And Patients in Surgical Consultations

Brandon Tran, Angelica Falkenstein, Kate Sweeny

Department of Psychology

ABSTRACT

Good communication within healthcare promotes greater patient satisfaction and adherence to doctor's recommendations. Medical interactions require a partnership between doctor and patient, each expressing and evaluating goals to create a plan of action through shared decision-making. In conversation, the use of pronouns has been found to represent attentional focus, whether on the self via singular first-person pronouns (I/me) or others via plural first-person pronouns (we/us) and second-person pronouns (you). Thus, the current study investigates whether pronoun usage by doctors (other-focused) or patients (self-focused) predicts healthcare consultation outcomes. Conversations between 149 patients (50.8% women, $M_{age} = 44.7$) and their 8 doctors were recorded, transcribed, and analyzed using text analysis software (Linguistic Inquiry and Word Count, LIWC) to identify and count pronouns used. Analyses confirmed that differences in doctors' and patients' use of pronouns during healthcare communication predicted positive consultation outcomes, including higher ratings of productivity and patient satisfaction.

Keywords: doctor-patient communication, pronouns, satisfaction, adherence

FACULTY MENTOR

Kate Sweeny

Department of Psychology

Professor Sweeny is an Associate Professor of Psychology. Her research examines two broad questions. First, how do people cope with uncertain waiting periods? Second, how should doctors talk to their patients? She has studied law graduates awaiting news about the bar exam, patients awaiting biopsy results, researchers awaiting manuscript decisions, surgeons talking to their adult patients, and asthma specialists talking to pediatric patients, among many other topics and studies.

AUTHOR

Brandon Tran

Department of Psychology

Brandon Tran is a third year Honors student majoring in Psychology. He has worked in Dr. Sweeny's lab since April 2014 and is interested in developing techniques to improve the quality of the patient healthcare experience. Additionally, Brandon has completed a research internship examining doctor-patient interaction and is working on his University Honors Capstone Project, investigating how the use of medical jargon by doctors predicts patient outcomes. He hopes to pursue a Ph.D. in health psychology after completing his undergraduate studies.

Within healthcare, communication between doctors and patients is foundational to the assessment of medical conditions and navigation of treatment options. Interactions within healthcare visits consist of a two-way exchange of information, from patient to doctor and doctor to patient, through the process of shared decision-making (Charles, Gafni, & Whelan, 1999). The shared decision-making model suggests a partnership between doctor and patient, granting each the opportunity to voice concerns regarding the medical situation and to navigate treatment options together (Charles, Whelan, Gafni, Willan, & Farrell, 2003). Although shared decision-making helps establish a course of treatment, following the doctor's recommendations (adherence) is the patient's responsibility. Strong communication through shared decision-making has been linked to greater adherence by patients (Zolnierek & DiMatteo, 2009). Thus, the present study aims to provide an in-depth examination of one aspect of healthcare communication: pronoun usage by doctors and patients during healthcare consultations.

When communicating with others, the use of pronouns reveals attentional focus within conversations. The use of singular first-person pronouns (I/me) signifies self-focus, whereas plural first-person pronouns (we/us) and second-person pronouns (you) imply other-focus (Ickes, Reidhead, & Patterson, 1986; Zimmermann, Wolf, Bock, Peham, & Benecke, 2013). (Atypon.) Within the context of healthcare, these findings suggest that patients (self-focused) might use more singular first-person pronouns as they describe their symptoms or medical situation, whereas doctors (other-focused) may use more second-person pronouns in the course of shared decision-making.

In addition to attentional focus, pronoun usage also represents differences in social status within a conversation (Kacewicz, Pennebaker, Davis, Jeon, & Graesser, 2014), such that lower-status individuals use more first-person pronouns (I/me) whereas higher-status individuals use more second-person (you) and third-person pronouns (he/she). Taken together, these findings suggest that doctors (higher-status) are more likely to use second-person pronouns and patients (lower-status, at least within the context of healthcare encounters) more first-person pronouns (*Hypothesis 1*).

Communication within the healthcare setting has a significant impact on patient adherence, well-being, and overall recovery (Zolnierek & DiMatteo, 2009). Research suggests that shared decision-making during healthcare consultations enables doctors and patients to effectively communicate, granting both an equal opportunity to exchange concerns and navigate medical situations together (Charles et al., 1999). Therefore, the current study seeks to examine how pronoun usage by doctors and patients relates to outcomes of healthcare consultations. Specifically, we hypothesized that greater use of singular first-person pronouns (I/me) by patients and greater use of plural first-person (we/us) and second-person pronouns (you) by doctors during pre-operative consultations would predict more positive consultation outcomes, including higher ratings of productivity by the doctor, greater patient satisfaction, and improvements in patients' emotional state (e.g., increased hopefulness, reduced nervousness; *Hypothesis 2*).

METHOD

Participants

A total of 383 patients and eight physicians from the general surgery clinic at a local regional hospital participated in this study (50.8% women, M_{age} = 44.7). Although approximately half of the sample completed high school (53%), many patients reported they did not earn a high school diploma (31%) and some earned a 2-year or 4-year college degree (16%). Approximately half of the sample (55%) were Hispanic/Latino. As we note below, only 149 patients are included in our analyses (i.e., those who had useable audio recordings of their consultation).

Approval for all procedures was obtained from both the Institutional Review Board at the University of California, Riverside, and the regional medical center. All participants provided informed consent prior to participation in the study.

PROCEDURE

Questionnaires. The data presented in the current study were collected as part of a larger project examining communication within healthcare, specifically in a

surgical context. Thus, the current study investigates verbal conversations between the surgeon and patient during pre-operative surgical consultations. Patients who participated in the study completed two questionnaires, the first prior to meeting with the doctor (pre-consultation), and the second immediately after meeting with the doctor (post-consultation). Doctors also completed a brief post-consultation questionnaire after meeting with the patient.

The pre-consultation questionnaire included measures of patients' current emotional state ("How hopeful/nervous do you feel right now?" 1 = *not at all*, 10 = *extremely*) and demographic information. Following the consultation, patients completed a questionnaire that included follow-up measures of patients' emotional state (same items as in the pre-consultation questionnaire), satisfaction with the doctor(s) they saw that day ("How much did you like the doctor(s) you saw today?" 1 = *not at all*, 10 = *extremely)*, and overall satisfaction with the visit ("How satisfied are you with your visit today overall?" 1 = *not at all*, 10 = *extremely*).

The post-consultation questionnaire administered to the doctor included an assessment of the doctor's overall satisfaction with the consultation ("Quality of today's visit"; 1 = *very unproductive*, 7 = *very productive*).

Consultation recordings and transcription. We used audio recordings to document the conversation between doctor and patient during each pre-surgical consultation, which we then transcribed into text files. Once transcribed, the text files were separated into individual speakers, isolating the doctor's and patient's word usage within each conversation. Next, the individual files were analyzed using Linguistic Inquiry and Word Count (LIWC) software (Pennebaker, Chung, Ireland, Gonzales, & Booth, 2007) to create doctor and patient word counts. LIWC is a word-counting program that analyzes a body of text, counting and categorizing specific words into various groups (e.g., pronouns, assertion words, health words, etc.). Of these categories, the current study focused specifically on the use of singular first-person (I/me), plural first-person (we/us), and second-person pronouns (you).

DATA ANALYSIS

The counts derived from LIWC and questionnaire data were quantified and analyzed through the statistical analysis program SPSS. Paired sample *t*-tests and correlations were conducted to examine differences between doctors' and patients' pronoun usage and their association with healthcare outcomes. For analyses examining patients' emotional state (i.e., nervousness, hopefulness), we first created a difference score by subtracting patients' initial emotional state (pre-consultation) from their final emotional state (post-consultation), such that positive numbers indicate increases in the emotion and negative numbers indicate decreases in the emotion.

RESULTS

Differences in Pronoun Use between Patients and Doctors

Results from paired-samples *t*-tests confirmed *Hypothesis 1*: Doctors tended to use more plural first-person pronouns (we/us; $M = 2.25\%$, $SD = 1.61\%$) than their patients ($M = 0.36\%$, $SD = 0.75\%$), $t(144) = 12.97$, $p < .0001$, and doctors also used more second-person pronouns (you; $M = 5.63\%$, $SD = 2.27\%$) than their patients ($M = 2.47\%$, $SD = 2.08\%$), $t(144) = 11.83$, $p < .0001$. Also consistent with *Hypothesis 1*, patients tended to use more singular first-person pronouns ($M = 8.03\%$, $SD = 3.48\%$) than their doctors ($M = 2.65\%$, $SD = 1.38\%$), $t(144) = 18.12$, $p < .0001$.

Word Use and Pre-Operative Outcomes

Table 1 presents the correlations between doctors' and patients' pronoun use and outcomes of the consultation. We summarize the findings below.

Correlates of doctors' pronoun usage. Correlations between pronoun usage during the consultation and post-consultation questionnaire data revealed that, consistent with *Hypothesis 2*, greater use of singular first-person pronouns (I/me) by doctors was associated with marginally lower ratings of consultation productivity by doctors and marginally higher ratings of satisfaction with the visit by patients. Doctors' use of singular first-person pronouns

Table 1. *Correlations between Pronoun Use and Consultation Outcomes*

	Doctor's Rating		Patient's Ratings		
	Consultation Productivity	Satisfaction with the Doctor	Satisfaction with the Visit	Change in Nervousness	Change in Hopefulness
Doctors' pronoun use					
Singular first-person	-.16†	.01	.15†	-.10	-.10
Plural first-person	.14†	-.06	.06	.03	.25**
Second-person	.19*	.02	-.12	-.07	-.13
Patients' pronoun use					
Singular first-person	-.21*	-.06	-.03	-.17†	-.06
Plural first-person	.17*	.01	.10	.05	-.02
Second-person	.12	.01	.19*	.06	-.11

Note: †$p < .10$ (marginal); *$p < .05$; **$p < .01$.

(I/me) did not reliably predict patients' satisfaction with the doctor, changes in patients' nervousness, or changes in patients' hopefulness following the consultation.

Also as hypothesized, doctors' use of plural first-person pronouns (we/us) during pre-operative consultations was associated with marginally higher ratings of consultation productivity by doctors and significant increases in patients' hopefulness following the visit. Doctors' use of plural first-person pronouns (we/us) did not reliably predict patients' satisfaction with the doctor, patients' satisfaction with the visit, or changes in patients' nervousness following the visit.

Contrary to our hypothesis, doctors' use of second-person pronouns (you) during pre-operative consultations predicted *lower* ratings of consultation productivity by doctors. Doctors' use of second-person pronouns (you) did not reliably predict patients' satisfaction with the doctor, patients' satisfaction with the visit, changes in patients' nervousness, $r(134) = -.07$, $p = .41$, or changes in patients' hopefulness.

Correlates of patients' pronoun usage. Contrary to *Hypothesis 2*, patients' use of singular first-person pronouns (I/me) during pre-operative consultations was associated with marginal *increases* in patients' nervousness following the visit and *lower* ratings of consultation productivity by doctors. Patients' use of singular first-person pronouns (I/me) did not reliably predict patients' satisfaction with the doctor, patients' satisfaction with the visit, or changes in patients' hopefulness.

In contrast, patients' use of plural first-person pronouns (we/us) during pre-operative consultations was correlated with higher ratings of consultation productivity by doctors. Patients' use of plural first-person pronouns (we/us) did not reliably predict patients' satisfaction with the doctor, patients' satisfaction with the visit, changes in patients' nervousness, or changes in patients' hopefulness.

Patients' use of second-person pronouns (you) during pre-operative consultations was correlated with greater satisfaction with the visit. Patients' use of second-person pronouns (you) did not reliably predict patients' satisfaction with the doctor, changes in patients' nervousness, changes in patients' hopefulness, or doctors' evaluations of consultation productivity.

DISCUSSION

The results of the current study extend previous findings regarding pronoun usage and social status (Kacewicz et al., 2014) and attentional focus (Ickes et al., 1986; Zimmermann et al., 2013). Our hypothesis that doctors would use more plural first-person (we/us) and second-person pronouns (you) and patients more singular first-person pronouns (I/me) was supported, suggesting that patients may be more self-focused and feel lower in status compared to doctors during healthcare interactions.

In contrast, we found mixed support for pronoun usage by doctors and patients as predictors of consultation

outcomes. Our results for doctors' use of plural first-person pronouns (we/us) support previous findings that shared decision-making facilitates good communication between doctor and patient (Charles et al., 2003; Charles et al., 1999). Doctors who tended to use more plural first-person pronouns (we/us) evaluated the visit as more productive and had patients who increased in hopefulness following the consultation. By utilizing more plural first-person pronouns (we/us), doctors may depict and verbalize a sense of partnership with patients, granting them an active role and sense of control over their condition and treatment. Similarly, these doctors may have evaluated the visit as more productive due to greater patient involvement in the consultation, building rapport and facilitating more effective communication with the doctor.

Contrary to our hypothesis, doctors who used more second-person pronouns (you) tended to evaluate the consultation as *less* productive. It may be that second-person pronouns convey a boundary between doctor and patient. By addressing the patient using "you" versus "we," doctors may abolish the partnership associated with effective shared decision-making. Additionally, doctors' use of second-person pronouns (you) may cause patients to feel disconnected from their medical professional, disrupting effective communication during the healthcare consultation and thus affecting patient outcomes.

Also contrary to our hypothesis, patients who used more singular first-person pronouns (I/me) tended to become *more* nervous following the visit, and their doctors evaluated the consultation as *less* productive. Although we anticipated that self-focus during a consultation would be appropriate for patients, given that their condition is the focus of the discussion, it may be that patients' use of singular first-person pronouns (I/me) indicates a sense of low status compared to the doctor (Kacewicz et al., 2014) and thus became anxious during the consultation. Additionally, patients' use of singular first-person pronouns (I/me) may reinforce the social boundary between patients and their doctors, rendering them as separate entities rather than as partners. This distinction may account for poorer evaluations of consultation productivity by doctors, as

patients who use lots of singular first-person pronouns (I/me) may be more "self-focused" and less cooperative.

Although we did not have a hypothesis regarding patients' use of plural first-person (we/us) or second-person pronouns (you), this type of pronoun usage seemed to be beneficial for both doctors and patients, as doctors evaluated consultations as more productive when patients used more plural first-person (we/us), and patients who used more second-person pronouns (you) were more satisfied with the visit. These unanticipated findings further suggest that patients who approach healthcare with a "team-oriented" mindset may experience better outcomes.

The results of the current study provide a rare look into the conversations and linguistic details of healthcare interactions. However, the results should be interpreted with caution due to limitations of the current study. Most notably, the sample recruited for this study was limited to patients at one medical center in Southern California. Additionally, only eight doctors participated over the course of the study, which may lead to results that are biased toward their particular conversation or care styles. Future studies should investigate whether the relationships between pronoun use and healthcare outcomes that emerged in our study can be replicated in larger samples of patients and doctors and in different geographical regions. This is the first study to investigate the specific linguistic details of conversation during healthcare consultations. The current study provides an in-depth look into patients' and doctors' pronoun use and their relationship with the outcomes of healthcare interactions. The results of our investigation highlight opportunities for doctors and other healthcare professionals to improve their methods of interacting with patients through nuances of conversation. Our findings suggest that when doctors and patients enter a consultation with the mindset of shared decision-making, as revealed through their use of plural first-person and second-person pronouns, both parties are likely to benefit. These findings provide an opportunity to promote a plethora of positive health outcomes, including increasing hope, promoting recovery from illness, and improving patients' overall well-being.

REFERENCES

Charles, C. A., Whelan, T., Gafni, A., Willan, A., & Farrell, S. (2003). Shared treatment decision making: What does it mean to physicians? *Journal of Clinical Oncology*, *21*(5), 932–936.

Charles, C., Gafni, A., & Whelan, T. (1999). Decision-making in the physician–patient encounter: Revisiting the shared treatment decision-making model. *Social Science & Medicine*, *49*(5), 651–661.

Ickes, W., Reidhead, S., & Patterson, M. (1986). Machiavellianism and self-monitoring: As different as "me" and "you." *Social Cognition*, *4*(1), 58–74.

Kacewicz, E., Pennebaker, J. W., Davis, M., Jeon, M., & Graesser, A. C. (2014). Pronoun use reflects standings in social hierarchies. *Journal of Language and Social Psychology*, *33*(2), 125–143.

Pennebaker, J. W., Chung, C. K., Ireland, M., Gonzales, A., & Booth, R. J. (2007). The development and psychometric properties of LIWC2007. *Austin, TX, LIWC.net*.

Zimmermann, J., Wolf, M., Bock, A., Peham, D., & Benecke, C. (2013). The way we refer to ourselves reflects how we relate to others: Associations between first-person pronoun use and interpersonal problems. *Journal of Research in Personality*, *47*(3), 218–225.

Zolnierek, K. B. H., & DiMatteo, M. R. (2009). Physician communication and patient adherence to treatment: A meta-analysis. *Medical Care*, *47*(8), 826–834.

From the Tomb to the Womb: Music as a Transgenerational Phantom in Chang's *Hunger*

Jacqueline Wong, Stephen Hong Sohn

Department of English

ABSTRACT

This essay applies psychoanalysis and trauma theory to Lan Samantha Chang's novella, *Hunger*, and examines how it fits within the literature of the Asian American immigration experience. I examine Chang's use of language to convey the music within her story and show how music functions as the transgenerational phantom that haunts the family from parent to child. This essay also posits the necessity of a witness, and how the characters need to express their trauma as a means of recovery. Utilizing these theoretical lenses, I ultimately argue that Chang's emphasis on music through language not only enhances the connection between the reader and the emotional trauma that the characters face, but also conveys the Asian American immigration novel in a unique manner.

Keywords: Psychoanalysis, Trauma Theory, Transgenerational Phantom, Melancholia, Witnessing, Asian American Literature

FACULTY MENTOR

Stephen Hong Sohn

Department of English

Stephen Hong Sohn, a former University of California President's Postdoctoral Fellow (2006-2007), has edited or co-edited a number of different works and special issues. His first book, (New York University Press, 2014), focuses on contemporary Asian American fictional production, social context methodology, and aesthetic practices. A second book is currently in progress, exploring gender and sexuality in Asian American cultural production. He also is founder and moderator of Asian American Literature Fans, an open access website devoted to reviews and discussions in the field.

AUTHOR

Jacqueline Wong

Department of English

Jacqueline Wong is a fourth year English major and University Honors student. She is currently working on her senior thesis project, "A Stray Princess: Composing Music for a Fantasy Story Containing a Prominent Female Hero." In the future, she plans on entering graduate school to further study how "Eastern" and "Western" cultural influences converge and create rich cultural hybrids through stories. She ultimately hopes to examine the significance of these products and what they say about, and how they fit into, our increasingly cosmopolitan world.

Since the 1850s, Asian American literature has provided insight into the complex cultural, social, and political outcomes of the Asian immigrant experience in America. Particularly after the Immigration Act of 1965, a new wave of Asians immigrated to America after the United States lifted its quota policy. Lan Samantha Chang's novella *Hunger* is a literary product of this movement, portraying a Chinese American family. In order to better understand common themes that appear in the Asian immigration narrative, such as problems with assimilation and intergenerational conflict between the Asian parent and the more Americanized child, this essay will apply psychoanalysis and trauma theory to Chang's novella. I argue that music and sound function as a transgenerational phantom that manifests itself through Tian and his daughters, Anna and Ruth. At the same time, the mother Min witnesses her family's traumas and recounts these stories to the reader as a ghost. Her role thus touches upon the necessity of a witness and how it affects the value of psychoanalysis and trauma theory within Asian American literature as a whole. Analyzing Chang's poetic use of language to convey the characters' trauma in relation to the music, I further contend that her novella is a uniquely artistic and emotional portrayal of the Asian American immigration experience.

Psychoanalysis studies the unconsciousness of the mind to reveal one's unknown psychological motives. One concept that is helpful in examining characters' unconscious is the transgenerational phantom, something that "haunts" through the "gaps left within us by the secrets of others… it is the children's or descendants' lot to objectify these buried tombs through diverse species of ghosts…the burial of an unspeakable fact *within* the love-object" (Abraham & Torok 172). This idea helps readers analyze Tian's traumatic experience that he keeps from his daughters and how it affects them. To become a professional violinist, Tian defied his family's expectations and escaped China by swimming onto a refugee ship. Aware that the "Communist government would not look favorably upon a family who had let a son run off to the West," his internal struggle of disappointing his family and external struggle of succeeding in a new country lingers within his music (Chang 29). Thus, the connection between the music and his past relates to how "the phantom's periodic and

compulsive return lies beyond the scope of symptom-formation in the sense of a return of the repressed; it works like a ventriloquist" that haunts Anna and Ruth throughout the novella (Abraham & Torok 173).

Another psychoanalytic concept that helps readers understand the Sung family is Freud's idea of melancholia. Freud explains that, "countless separate struggles are carried on over the object, in which hate and love contend with each other; the one seeks to detach the libido from the object, the other to maintain this position of the libido against the assault" (256). This "lost-love object" is a person, place, or idea that the victim loses along with a part of his ego (Freud 245). As a result, the melancholic constantly desires to reinforce the lost part of the ego through an imperfect replacement. Considering Tian's past, his lost love-object is his family he left in China whom he vows to never think about, believing that "there is only one thing in life that I can permit myself to do. Anything else—frightens me. I am not allowed to have it" (Chang 28). In other words, Tian feels immense pressure to succeed due to the guilt he suffers from abandoning his family and country. Tian's estrangement from his family thus leads to his melancholia and facilitates his "self-punishment, in taking revenge on the original object and in tormenting their loved one through their illness" (Freud 251). These symptoms of melancholia are demonstrated through his deteriorating relationships with his family members, influencing their character trajectories throughout the novella.

Understanding the psychoanalytic concepts from above illustrates Chang's use of language and how she conveys music in a way that haunts Tian's daughters. In Anna's case, he projects his failure of becoming a professional violinist onto her. For example, he becomes upset after he discovers that "she had a mediocre sense of pitch...she could not sense the spot where the desired note sang out clearly, sweetly, without dissonance" (Chang 54). Tian's negative reaction is attributed to his melancholia, which drives him to initially seek his imperfect replacement through Anna. His desperation further intensifies after he is denied tenure at the music school due to his limited English proficiency. Min suspects that, "someone had decided he would not be hired for a permanent job," and therefore

did not suggest that he improve his English earlier; "They had held onto him while knowing they had no place for him…Without the school, we had no money and no green card" (Chang 48). This suggests that Tian was subjected to racial discrimination and exploitation from the music school, leaving him dejected as his immigration status prevents him from achieving his dream. Tian, as a result, loses another love-object. Therefore, when Tian realizes that Anna cannot become his replacement, he associates her with "his own struggle; he hated her difficulties, but he especially hated his own" (Chang 55). In other words, Tian feels even more disappointed in himself due to his inability to become a concert violinist despite his great sacrifices, which also fuels Anna's insecurity.

Through the music played within the house, Anna senses Tian's transgenerational phantom, motivating her desire to understand him. Even as an infant, Anna "started to follow him to the practice room…siting outside its closed door" (Chang 32). Her longing behavior toward her father demonstrates symptoms of melancholia, as Anna desires to retrieve her lost love-object, or her father's love, through the violin. However, when Anna tries to advance, she finds that the "patterns" are "intricate, evasive, hard to hold in the mind. Each new section of the piece seemed to layer difficulty on the last, bringing out new weaknesses in her, relentless, stubborn weaknesses that were revealed day by day" (Chang 55). The words Chang uses to convey Anna's futile efforts reveal her desperation for Tian's love. Unbeknownst of his secret, when Tian tells Anna to go away after realizing that she will not excel at the violin, she internalizes his rejection. Anna's lack of pitch represents and reinforces her inability to access Tian's past, as the door to his practice room will now always be closed to her. Her shortcomings frustrate her even further as Tian forcefully continues his lessons with Ruth. The music thus reminds Anna of her inability to receive Tian's love, facilitating her melancholia throughout the rest of the novella.

Anna's melancholia drives her to find other means to understand Tian in an attempt to retrieve her lost love-object. Resenting her inability to seek the truth through music, she asks Min, "Why did you and Baba leave China?" (Chang 65). Anna's uncharacteristic forwardness with her question reflects how "the patient appears possessed not by his own unconscious but by someone else's" (Abraham & Torok 173). Anna is thus haunted by her father's secret and she studies Chinese history in college in order to unravel it. Specializing in the Communist period when Tian still lived in China, Anna seeks to "tape and transcribe a series of interviews in which he described his childhood and the way he remembers the events of that time" (Chang 82). Her interest in Chinese history demonstrates her desire to get closer to Tian and understand why music is so important. Studying Chinese history is thus her means of figuring out what drives Tian's hunger, and how music became a source of unhappiness for her and her family. Unable to sufficiently answer these questions, Anna still lives in the apartment after Ruth leaves and her parents die. Min reflects that, "Perhaps she has been dreaming of her greatest hope and fear—that the house is gone, that it is destroyed, and nothing more remains of it" (Chang 114). Thus, the music, and Tian's phantom trapped within it, continues to facilitate her melancholia. Anna is unable to move on from the past and her unresolved questions continue to haunt her, compelling to stay at home.

Tian's relationship with Ruth is also strained due to music's role as the transgenerational phantom. Abraham and Torok note that, "It is crucial to emphasize that the word giving sustenance to the phantom return to haunt from the unconscious. These are often the very words that rule an entire family's history and function as the tokens of its pitiable articulations" (176). In other words, music facilitates the family's dysfunction. Unlike with Anna, Tian favors Ruth because "she resembles my family" (Chang 43). The way that Tian associates Ruth with his past demonstrates his inability to resolve the loss of his family in China. His favoritism toward her is especially displayed through the violin. For example, during the pivotal scene where Tian pushes Ruth to practice in Anna's place, Tian suddenly makes a "sharp and monstrous *bang*. He had struck the top of the piano…'You go ahead and cry!' His voice broke and climbed upwards…Again, the bang of his hand hitting the piano…'you cry! But—*play*!'" (Chang 59). The harsh sounds he produces by banging the piano demonstrate the violent fervor of his hunger. He also keeps striking the piano, representing the incessantness of his desire. The shrill of his rising voice also reveals the transforming effect his hunger has on him, turning him into

a monster that neglects his daughter's feelings. The fact that his voice breaks also expresses the pain he suffers in leaving his family and failing to achieve his dream. Tian's ruthlessness toward Ruth ultimately shows how he makes her his imperfect replacement of his combined lost love-objects. His sudden strictness and unrelenting attitude toward Ruth thus represents how closely he ties his past and future onto her.

Tian and Ruth's turbulent relationship is portrayed through the sounds and music within the Sung household. These sound effects represent Tian's melancholia and how he projects his frustrations on "someone else, someone whom the patient loves or has loved or should love" (Freud 248). As a result, Tian treats Ruth as relentlessly as he does himself, filling the house with "the struggle of commands and sobs" (Chang 62). Despite Tian's treatment, Ruth would just "play and sob for hours" because she "had known from infancy, that she held him in her hands. Now he had replaced his tenderness with his stern passion and she followed him there, believing the source of his sternness lay in love." By associating sternness with Tian's love and hunger, Chang illustrates the complex emotions Ruth suffers through. The reader thus sees how Tian's transgenerational phantom traumatizes Ruth, especially since she does not know his secret. Yet amidst the chaos of their relationship, "the pure melody of the violin rising over all of it like a great rope of silk, smooth and shimmering, shot through with glints and shades of beautiful light" (Chang 61). By comparing the music to the visually stunning silk, Chang ties the music's beauty together with Tian's hunger. Thus, the beautiful music that is produced amongst the agonizing struggle represents Tian's and Ruth's relationship: both tragic and yet full of love.

However, Tian's obsessive struggle to contain Ruth as his imperfect replacement further deteriorates their relationship with each other, reproducing cycles of trauma through the generations. During Ruth's concert performance, she produces beautiful music: "There was no anger there, none of Tian's bitterness, but youth, sweet youth, drawn from her father's old instrument. The music flowed around us, soothed us and excited us, pulled us away; far away, from ourselves" (Chang 68). The pulling and soothing motions

of her music connects back to Tian's experience on the boat fleeing from China. While watching Ruth, he "sat listening as if to a beloved voice, indelible and persisting over time… unable to take his tortured, joyful eyes away form the stage" (Chang 69). Chang's word choice shows how music transcends through time and brings up memories of the past that haunt Tian, yet soothes him at the same time. As a result, Tian wants to keep Ruth, as she embodies everything that he cannot have. When Ruth wants to switch teachers, he asserts, "You're my daughter and I'm your father!" indicating possessiveness over her (Chang 72). As a result, Ruth begins to mirror and reproduce Tian's actions when he ran away from his parents, and Tian begins to mirror his parents'. For example, when Ruth finally quits the violin, Tian yells back, "Then I don't want you! You are not my daughter! You are nothing!" (Chang 88). The finality of his words drives Ruth to leave, as his father's words did for him.

Furthermore, Min witnesses Tian trauma through his music as it acts as his unspoken secret. In doing so, she observes, "The victim's narrative—the very process of bearing witness to massive trauma—does indeed begin with someone who testifies to an absence" (Laub 57). She also pieces together Tian's secret "scratched out in deep wounds" to understand the depths of his trauma (Chang 112). For example, during Tian's concert performance, Min describes his music with violent language. Tian plays like a "hawk" ready to strike his "victim" with "a clear intensity; each note attacked the air, quick and piercing as a dagger" (Chang 20). The hawk imagery Chang employs portrays Tian as constantly closing in and, attacking the music, or "victim," to devour it. The dagger also reinforces this predator vs. prey motif, representing the sharpness of a hawk's beak, and Tian's violence. By witnessing his performance, Min recognizes the depths of Tian's hunger that he had not directly expressed to her earlier, revealing how painful his sacrifices were in abandoning family to become a professional violinist. At her ignorance, she reflects, "how could I have chosen such an unforgiving man? I knew nothing about music, but I could hear in these sounds a man who would accept no excuse form anyone or anything close to him" (Chang 20). Tian's manner of playing music relates to how, "trauma is constituted not only by the destructive force of a violent event but by the very act of its survival" (Caruth 25). Thus,

Tian's tumultuous relationship with music serves as a way for him to process and express his trauma, as he literally needs an audience to listen to his music.

Min also uses music as a means of witnessing her daughters' trauma as they suffer through Tian's transgenerational phantom. Since the beginning of the novella, Tian's music absorbs "deep within the wall," and Min hears the "swooping" and "dizzying" sounds, making her feel as though the room "[pitches] up and down like a ship on a swell" (Chang 17-18). These swooping descriptions also refer back to Tian's predatorily hawk-like nature when he plays the violin. The ship imagery also touches upon Tian's experience smuggling himself onto the ship, to escape China. Hearing the depths of Tian's trauma, Min reflects how the ship could "have failed to creak and shudder beneath the weight of this man's desire? The immensity of such hunger" that drove him to forsake his family (Chang 113). Min's imagery also demonstrates her use of narration to patch together Tian's past and how the music affects her daughters. For example, Min witnesses how music makes Anna feel unworthy of her father's love and inferior to her sister. When Anna hears Ruth surpass her on the violin, Min sees that "She sat with tears running down her face, clutching a pair of underpants, tearing it in her hands" (Chang 60). The way that Anna tears at the fabric signals not only her own heartbreak, but also how Min's narrative of Tian is torn apart. Min's efforts to understand Tian's past and justify his actions rip away due to his unforgiving behavior towards his daughters, and how he reproduces cycles of trauma onto them. Anna's tearing of the fabric also signifies Min's melancholia and her lost love-object: a happy family.

In addition, Min witnesses how cruelly Tian treats Ruth through the music. During the practice scene when Tian becomes stern with Ruth, Min hears Ruth's desperate protests and Tian's relentlessness, " 'No, no, no, no—' Her voice rose to a shriek. There was a slam as he closed the door, and they were trapped inside the room together" (Chang 60). The harsh sounds that Tian makes by slamming the door and banging the piano are reminiscent of his intense, unyielding approach towards music. Closing the door with Ruth also solidifies his decision to make her his imperfect replacement, entombing them together. As a proper witness, Min should demonstrate "an outstanding measure of awareness and of comprehension of the event…that it was beyond the limits of human ability (and willingness) to grasp, to transmit, or to imagine" (Laub 68). Yet when she hears Ruth's trauma, she reflects, "despite my efforts I began to hear…above his banging and her wailing, the fragile, turning rhythm of a waltz… Somewhere through all this mad coercion ran a thread of beauty" (Chang 60). This quote reveals her reluctance to accept the trauma her family was experiencing through Tian's ghosts. Using thread imagery to describe the music is thus a way for Min to construct a narrative of her own trauma she experienced as Tian's wife. At the end of the novella, she even reflects that, "I could not face the fact that I had allowed my daughter to be subject to her father— to his unremitting desires, his stubborn memories, his fury and personal disappointment" (Chang 83). These quotes further reveal Min's melancholia after losing the happy family she desires.

By recounting her own experiences to the reader, Min "lingers in these walls," just like the music (Chang 114). Telling her story as a ghost, her desire to stay within the household further represents her melancholia at having lost a happy family. The way that Min fixates on the sounds of the house serves as further proof: "Blunt chords of anger; fragile notes that barely whisper. I hear the sorrow that seems to run in all our blood, and also an unbreakable thread of love." Again, Min uses thread-like imagery to weave through a patchwork of sounds that represent the love and sorrow of her family's trauma. Min's behavior thus reflects what Caruth says about the necessity of a witness, "The return of the traumatic experience in the dream is the attempt to overcome the fact that it was not direct, to attempt to master what was never full grasped in the first place" (Caruth 25). In other words, Min needs to tell her story to the audience in order to make sense of her family's trauma. Her inability to move on also demonstrates that she still has not resolved the loss of her family. Laub further adds that, "repossessing one's life story through giving testimony is in itself a form of action, of change, which one has to actually pass through, in order to continue and complete the process of survival
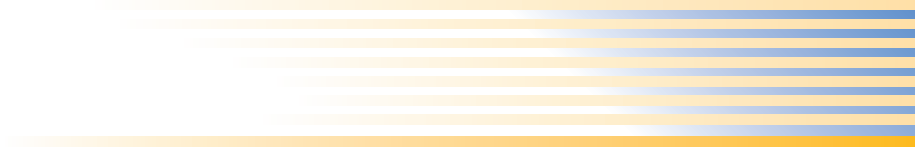
after liberation" (Laub 70). Thus, by telling her story to the audience, Min exerts her own agency by processing and constructing a narrative of her family's trauma as a way of recovery.

Min's interpretation of her family's story provides an account of the Asian American immigration experience. Through the language that Chang employs, the reader can sense, and almost hear, the characters' trauma and emotions through the music. Psychoanalysis offers the reader insight on the music's role, as it substitutes what the characters cannot or are unwilling to say due to their trauma. In her ghost-like state, Min furthermore addresses the value of the witness, claiming that she haunts the house because "there might come a time when no one on earth will remember our lives" (Chang 114). Her ultimate fear thus points to the value of trauma theory: to unpack the immigrant experience as a means of understanding and recovery from the trauma. Because she is unable to resolve the loss of her family, Min cannot act as a witness to her own trauma, and her fears relate to the absence of a witness, resulting in the "ultimate annihilation of a narrative that, fundamentally, cannot be heard and of a story that *cannot be witnessed*" (Laub 68). Thus, the readers must act as witnesses in order to understand this family's story, as well as for the characters to undergo a process of recovery. Chang's use of language to convey the music beautifully illuminates the emotional intensity her characters face within the narrative of an Asian American immigration novel. The music thus enhances the emotional connection between the characters, their trauma, and the reader, portraying this Asian American story in a unique manner within the realm of its literary genre.

WORKS CITED

Abraham, Nicolas, Maria Torok, and Nicholas T. Rand. "Notes on the Phantom: A Complement to Freud's Metapsychology." *The Shell and the Kernel: Renewals of Psychoanalysis*. Chicago: U of Chicago, 1994. 172-76. Print.

Caruth, Cathy. "Violence and time: traumatic survivals." *Assemblage* (1993): 24-25.

Chang, Lan Samantha. Hunger: A Novella and Stories. New York: W.W. Norton, 2009. Print.

Felman, Shoshana, and Dori Laub. "Truth and Testimony." *Testimony: Crises of Witnessing in Literature, Psychoanalysis, and History*. New York: Routledge, 1992. 61-74. Print.

Felman, Shoshana, and Dori Laub. "Bearing Witness or the Vicissitudes of Listening." *Testimony: Crises of Witnessing in Literature, Psychoanalysis, and History*. New York: Routledge, 1992. 57-71. Print.

Freud, Sigmund, Alix Strachey, Alan Tyson, and Anna Freud. *The Standard Edition of the Complete Psychological Works of Sigmund Freud: Early Psycho-analytic Publications*. London: Hogarth, 1975. 243-58. Print.