Journal of Undergraduate Research

JUR Press
Office for Undergraduate Research and Artistry
The Institute for Learning and Teaching
Colorado State University
Campus Delivery 1052
200 W. Lake Street
Fort Collins, CO, 80521-4593
Phone: (970) 491-4156
Web: *jurpress.org*

Designers: Katie Brown
Cover art: Microcosm

ISSN: 2156-5309

Printed in the United States of America

Author Inquiries: For inquiries relating to the submission of articles please visit *jurpress.org.*

Editorial Staff

Editor in Chief
Ryan Rykhus/Katie Brown

Managing Editor
Katie Brown

Associate Editors/Copy Editors
Reagan Fitzke
Alex Frickenstein
Zach Shepard
Caroline Wendt
Logan McCoy

Affiliate Editors
Cassie Gardner
Jordan Becker

Advisory Board

Graduate Advisor
Dr. Melissa Edwards
PhD in Cell & Molecular Biology,
Colorado State University

Faculty Advisor
Dr. Mark Brown
Veterinary Medicine and Biomedical Sciences
Director of the Office for Undergraduate Research and Artistry

Industry Liaison and Contributing Editor
Jessica Egner

Faculty Advisory Board
Dr. Susan Athey
Business
Dr. Mark Brown
Veterinary Medicine and Biomedical Sciences
Dr. Stephan Weiler
Liberal Arts
Dr. Chris Myrick
Natural Resources
Dr. Matt Hickey
Health and Human Sciences
Dr. Nancy Irlbeck
Agricultural Sciences
Dr. Don Mykles
Natural Sciences
Dr. Tom Siller
Engineering

A Letter from the Editor in Chief

JUR Press is proud to present Volume IX of the Journal of Undergraduate Research with published works across a wide range of disciplines by undergraduates from around the world.

We are a journal for undergraduates and by undergraduates. Our slogan – linking the global undergraduate community – captures our mission to serve the interests of worldwide undergraduate thinkers, tinkerers, experimenters, writers, and artists. While JUR does provide a platform for students to publish and showcase their work, we also give students the opportunity to learn about the publication process from start to finish through internships as editors, operations associates, and reviewers. Our undergraduate network has grown to include not only international authors, but also affiliate and satellite editors from around the world! We are truly committed to enhancing the undergraduate experience, and we continually seek to engage as many undergraduate students in our organization as possible.

This year has been a blessing as I have settled into the role of editor in chief with support from those around me. I am honored to have such a strong foundation built from all staff members and the entire JUR network. As seniors graduate and pursue their future and new members join to engage in the publication process, I am reminded of the hard work, determination, and dedication every present and past JUR member has done to better the organization and themselves. I have seen each member this year grow and truly embrace the meaning of "interdisciplinary" as they manage academics, internships, sports, volunteer positions, and take time out of their day to make someone else's. I am incredibly thankful for the laughs and smiles that each unique personality brought throughout the year to complete this edition.

For all that we have accomplished this year, I want to say congratulations to each member and how incredibly thankful I am for their efforts. You are exceptional individuals with a wide range of talents. I look forward to what the future has to offer for those graduating, and what the year holds for new and returning members.

To our published authors, I congratulate each of you on your accomplishment and we are thankful to have been part of your undergraduate academic experience.

Yours truly,

Katie Brown
Editor in Chief
Journal of Undergraduate Research
JUR-Press

Special Thanks

This publication would not have been possible without Colorado State University and the contributions of numerous advocates and benefactors.

JUR Press would like to thank our Faculty Supervisor, Dr. Mark Brown, the Faculty Advisory Board, and our Graduate Advisor Melissa Edwards. We would also like to thank our partners at the Autonomous University of the Yucatán, in Mexico, and Schreiner University in Texas.

Table of Contents

Title	Author	Page
Isolation of Full-Length Wild-Type LGN Protein	By Adam Howard, Ryan Elnicki, Autumn Smith, Justin Galardi, Mikalia Thomas-Ibitoye, Kyle Cohen, Laurie B. Cook, Ph.D, and Brandy Sreeilayam, Ph.D *University of York*	1
Readability and Length of High Risk Consent Forms	By Jonathan Burns, Tracy S. Ziolek, and Karen J. Tietze *University of the Sciences*	5
An Evaluation of Some Herbal Medicines Used in the Treatment of Typhoid Fever	By Mordecai James *Ahmadu Bello University*	10
Outdoor Recreation Motivations and Constraints of South Dakota Residents	By Paige E. O'Farrell, B.S., and Hung-Ling (Stella) Liu, Ph.D. *South Dakota State University*	14
Germany's Children: Marriage and Reproductive Policies under National Socialism during World War II	By Samantha Sullivan *University of Vermont*	18
Experimental Progress Towards Testing the Behavior of Gravity at the 20-micron Distance Scale	By M.P. Ross[1], J.S. Johnson[1], I.S. Guerrero[1], H.F. Leopardi[2], and C.D. Hoyle[1] *[1]Humboldt State University* *[2]University of Colorado Boulder*	23
Assessing the Ability of Incipient Basaltic Soil to Support Plants Native to Southwestern United States	By Antonia L. Jim[1], Aditi Sengupta[2], Ph.D *[1]Fort Lewis College* *[2]University of Arizona*	30
Temporal Variability of Soil Seed Banks in Lodgepole Pine Forests	By John A.F. Wendt and Mark W. Paschke *Colorado State University*	34
Assessment and Identification of Services for First Generation College Students	By Desiree Strange, Isabel Briseño, Alexis Gilbert, and Amanda Rivera *Tarleton State University*	38
Do Mental Capacity Laws Unfairly Discriminate Against People with Disabilities?	By Matthew Grace *University of York*	43
International Developments Grab of Forests in the Global South	By John Mark Shorack *San Diego State University*	47
"Heigh Ho" to "Let it Go": The Evolution of Gender Performance in Disney Princess Films	By Hayley Kessler, BA, BS, Breanna Dennes, and Milton Wendland, PhD *University of South Florida*	50

Isolation of Full-Length Wild-Type LGN Protein

By Adam Howard, Ryan Elnicki, Autumn Smith, Justin Galardi, Mikalia Thomas-Ibitoye, Kyle Cohen, Laurie B. Cook, Ph.D, and Brandy Sreeilayam, Ph.D

University of York

Abstract

LGN, named for the many repeats of the amino acids leucine (L), glycine (G), and asparagine (N), is crucial for mammalian cellular division. Specifically, LGN plays a significant role in cell polarity and alignment of the mitotic spindles and, in its absence, the organism ceases to develop. LGN has been shown to be upregulated in multiple clinical breast cancer cells and several breast cancer cell lines, and mutations in LGN have resulted in Chudley-McCullough syndrome and non-syndromic hearing loss DFNB82. The goal of this project was to overexpress and isolate full-length, wild-type LGN protein so that it could be purified to 95% and protein crystals could be grown to result in a 3-D structure of LGN. To date, full-length LGN has only been isolated in the presence of Gαi and the end product was not 95% pure. Furthermore, several crystal structures of LGN have been solved, but none are of the full-length LGN. It was discovered that overexpression of LGN in E. coli cells resulted in significant degradation of the protein, so a mammalian system was utilized for expression. Wild-type LGN has been overexpressed transiently in baby hamster kidney (BHK)-570 tissue culture cells using a pCMV-LGN plasmid and LipoD 293 reagent. Sonication was used to break open the BHK-570 cells to preserve the native structure of LGN, and then LGN was isolated by performing a modified immunoprecipitation in which a rabbit anti-LGN polyclonal antibody and Protein A/G Plus-Agarose beads captured the LGN protein and a synthetic LGN peptide released the LGN protein. It was estimated that about one-third of the total LGN protein was isolated using the current protocol, so optimization is necessary before scaling up the process. Ultimately, solving the crystal structure of wild-type LGN may facilitate the process of novel treatments for breast cancer, Chudley-McCullough syndrome and non-syndromic hearing loss DFNB82.

Introduction

LGN protein is named due to the presence of ten leucine (L), glycine (G) and asparagine (N) repeats in the N-terminal half of the protein; its official name as approved by HUGO Gene Nomenclature Committee is G-Protein Signaling Modulator 2 (GPSM2).[1] It has a molecular mass of 76 kDa, a basal pI of 6.49, and is expressed in a variety of tissue including: brain, heart, lung, liver, pancreas, spleen, kidney, testis, ovary, and skeletal muscle.[1,2,3] It has been shown that LGN is critical in the receptor-independent G-protein signaling pathway that regulates mitotic spindle orientation in cellular division.[4,5,6]

Due to the important role LGN plays in cellular division, it is not surprising that LGN is involved in multiple medical conditions. Clinical breast cancer cells have shown upregulation of LGN in comparison with normal mammary epithelial cells.[7] In cancerous MCF7, MDA-MB-231, and T47D tissue culture cells, the localization of LGN mimicked the localization observed in noncancerous culture cells; LGN was in the cytoplasm during interphase and moved to the spindle poles during metaphase and anaphase.[7] It was determined that the T450 residue of LGN was phosphorylated by the serine/threonine kinase PBK/TOPK in the breast cancer cell lines, and knocking down the activity of LGN using siRNAs resulted in significant growth reduction in T47D tissue culture cells.[7] Overexpression of a T450A mutant of LGN also suppressed cell growth in non-cancerous COS-7 culture cells.[7] Another medical condition in which LGN is altered is Chudley-McCullough syndrome (CMCS), an autosomal-recessive disorder characterized by early and severe onset of sensorineural deafness and various abnormalities in the brain.[8,9,10] Thus far, it has been determined that several different pathological mutations have led to truncations of the LGN protein, causing CMCS.[8,9,10] Finally, two different nonsense mutations in LGN have been discovered in patients with autosomal recessive non-syndromic hearing loss DFNB82.[11,12] Nonsyndromic hearing loss is a partial or total loss of hearing that is not associated with other signs and symptoms affecting other parts of the body, and the effects patients experience vary greatly depending on which gene contains the mutation.[11,12]

LGN was initially classified as a mosaic protein with two distinct domains.[1] The N-terminal domain of LGN consists of eight tetratricopeptide repeat (TPR) motifs which can bind to a wide range of protein targets, including nuclear mitotic apparatus protein (NuMA), an F-actin binding protein Afadin, and the multidomain protein Frmpd4 (also known as Preso1).[13-17] Specifically, TPR5-8 interact with NuMA and TPR2-6 interact with Frmpd4.[17] The C-terminal domain contains 4 GoLoco (GL) domains, also known as G-protein regulatory (GPR) domains, which bind to $G\alpha_i$-GDP subunits independently of each other and with high affinity.[1,18] Within the GL domains, there is a highly conserved D/EQR triad called an arginine finger, which binds to the Ras-like and all-helical domains of $G\alpha_i$-GDP.[19] Interestingly, GL1-2 and GL3-4 domains bind to TPR0-3 and TPR4-7 motifs respectively, resulting in a closed, auto-inhibited conformation of LGN.[4] A truncated LGN crystal structure also shows that GL3-4 domains form a pair of parallel α helices and bind to the concave surface of the TPR4-7 motifs, thus preventing LGN from binding to other proteins.[4] When $G\alpha_i$-GDP binds to the GL domains, the TPR motifs are released from the GL domains, thus allowing the TPR motifs to interact with their binding partner proteins NuMA, Afadin, or Frmpd4.[17] The crystal structure of the GL3-4 domains bound to TPR4-7 motifs reveals a slightly different conformation of the GL domains compared to the crystal structures of GL3 or GL4 domains bound to $G\alpha_i$-GDP.[4,20] Furthermore, there is less than 50% overlap in the amino acids of the

GL3-4 motifs that interact with $G\alpha_i$-GDP and TPR4-7 domains.[4] To date, there are no protein structures of the full-length LGN protein and, thus, there is no information about the region of LGN that connects the N-terminal TPR motifs and the C-terminal GoLoco domains.

The long-term goal of this project is to purify full-length, wild-type LGN protein to 95% purity and grow protein crystals for protein X-ray crystallography. This paper focuses on the short-term goal of isolating LGN from baby hamster kidney (BHK)-570 tissue culture cells. Overexpression of full-length LGN protein was attempted in the lab in *E. coli* cells, but there was significant protein aggregation, so a mammalian system was used. The purification of full-length LGN had been reported using *Sf9* cells, but it was in complex with $G\alpha_i$-GDP and the purity was less than 95%.[21] In order to isolate the full-length LGN from transfected BHK-570 tissue culture cells, cell membranes were broken using sonication, then a modified immunoprecipitation reaction was used in which the LGN protein is captured using a rabbit anti-LGN antibody and Protein A/G Plus-Agarose beads. The LGN protein is then released by adding the synthetic LGN peptide that was used to generate the LGN antibody sequence. The presence of LGN in the supernatant fractions of a Western blot indicated that the LGN protein has successfully been competed off the antibody by the peptide.

Methods

LGN Expression in BHK-570 Tissue Culture Cells

The full-length, wild-type pCMV-LGN plasmid was purchased from OriGene and transformed in DH5α cells. A 1 mg/mL stock of pCMV-LGN was isolated using a maxi-prep and stored at -20 °C until needed. BHK-570 tissue culture cells (obtained from ATCC) were grown in DMEM growth media containing 10% FBS at 37 °C and 5% CO_2. For LGN isolation experiments, the BHK-570 tissue culture cells were grown to 80% confluency in 10 cm dishes before the transfection protocol was performed using LipoD293 DNA In Vitro Transfection Reagent, per the manufacturer's, SignaGen Laboratories, protocol. Cells were allowed to express LGN protein for 24 hours for the isolation experiments.

Lysis of the BHK-570 Tissue Culture Cells

BHK-570 tissue culture cells were either lysed with a buffer or by sonication. For the lysis buffer procedure, BHK-570 tissue culture cells were rinsed with ice cold PBS three times in the 10 cm dishes. One mL of lysis buffer (50 mM Tris-HCl (pH 7.0), 150 mM NaCl, 1% NP-40, 1 mM EDTA, 1:1000 protease & phosphatase inhibitors (purchased from Sigma-Aldrich)) was added to each dish on ice for 5 minutes. The cells were scraped off the dishes and the lysates were transferred to chilled microfuge tubes, incubated on ice for 20 min, and centrifuged at 13,200 rpm for 10 minutes at 4 °C. The supernatants were transferred into new chilled microfuge tubes and stored at 4 °C until ready for use. For the sonication procedure, BHK-570 tissue culture cells were rinsed with ice cold PBS three times in the 10 cm dishes. One mL of sonication buffer (50 mM Tris-HCl (pH 8.0), 150 mM NaCl, 1 mM EDTA, 1:1000 protease & phosphatase inhibitors (purchased from Sigma-Aldrich)) was added to a 10 cm dish. Cells were scraped off the dishes and the lysates were transferred to chilled microfuge tubes and centrifuged at 13,200 rpm for 5 min at 4 °C. The supernatants were discarded and 500 µL of sonication buffer was added to the pellets. Microfuge tubes were sonicated for a total of 10 seconds in pulse mode (5 seconds on followed by 30 seconds off). Microfuge tubes were centrifuged at 13,200 rpm for 5 min at 4 °C and the supernatants were transferred into new chilled microfuge tubes and stored at 4 °C until ready for use.

Isolation of LGN

One µL of rabbit anti-LGN polyclonal primary antibody (1 mg/mL; purchased from Aviva Systems Biology) was added to the supernatant microfuge tubes, and the mixtures were gently rocked overnight at 4 °C. Sixty µL of protein A/G Plus-Agarose beads (purchased from Santa Cruz) were added and gently rocked at 4 °C for one hour. The microfuge tubes were centrifuged at 13,200 rpm at 4 °C for 2 minutes. The supernatant fraction was removed and labeled S*. The pellets were washed with either 500 µL of lysis buffer or sonication buffer three times. The pellet was resuspended in 300 µL of lysis buffer or sonication buffer and the lysate was equally distributed to 3 new microfuge tubes. Various amounts of LGN peptide (1 mg/mL; purchased from Aviva Systems Biology) and additional NaCl (0-350 mM) were added to the tubes and incubated overnight at 4 °C with gentle rocking. The microfuge tubes were centrifuged at 13,200 rpm at 4 °C for 5 minutes and 90 µL of the supernatant was transferred into 3 new chilled microfuge tubes. The supernatant microfuge tubes were centrifuged at 13,200 rpm at 4 °C for 5 minutes and 80 µL of the supernatant was transferred into 3 new chilled microfuge tubes (S1-S3). Pellets were washed with 200 µL of lysis buffer or sonication buffer 3 times, discarding the supernatant after each wash (P1-P3). The presence of LGN was determined by SDS-PAGE (10% gels) and Western blot analysis using PVDF membranes, rabbit anti-LGN polyclonal primary antibody (1:1000; purchased from Aviva Systems Biology) in 5% milk, and goat anti-rabbit IgG-HRP secondary antibody (1:5000; purchased from Fisher Scientific) in 5% milk. Detection of LGN bands was determined by film or computer imaging software (LI-COR C-Digit Blot Scanner).

Results

LGN protein was first attempted to be overexpressed and purified in *E. coli* using pET15b-LGN and pET28a-LGN vectors, but the SDS-PAGE and Western results

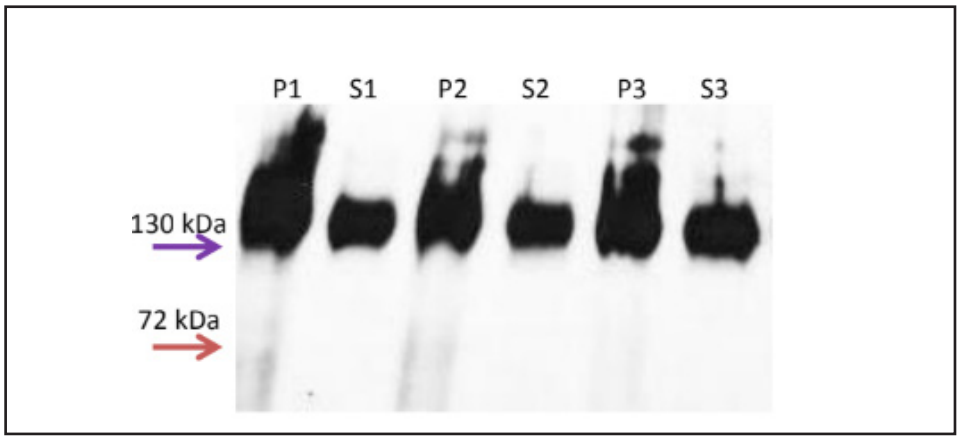

Figure 1: Isolation of LGN after lysing the BHK-570 tissue culture cells with lysis buffer. LGN protein was released from the antibody in the presence of 2 µg of peptide and various amounts of NaCl (100-500 mM). Lane contents from left to right: P1, S1, P2, S2, P3, S3. Orange arrow – 72 kDa; Purple arrow – 130 kDa.

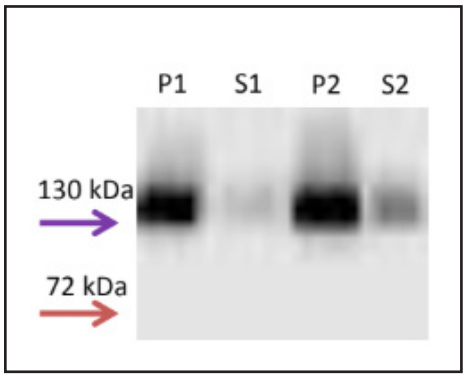

Figure 2: Isolation of LGN after sonication of the BHK-570 tissue culture cells. LGN protein was released from the antibody in the presence of 1 (left 2 lanes) or 2 µg (right 2 lanes) of peptide. Lane contents from left to right: P1, S1, P2, S2. Orange arrow – 72 kDa; Purple arrow – 130 kDa.

indicated significant degradation of the protein (data not shown). The mammalian cell line of baby hamster kidney (BHK)-570 tissue culture cells was then utilized. The isolation of LGN was first attempted using lysis buffer to break open the BHK-570 tissue culture cells. The cytosolic LGN protein that was expressed by the cells was captured in the pellet fraction using the anti-LGN primary antibody and protein A/G agarose beads. In order to compete LGN into the supernatant fraction, 2 µg of the peptide that was used to generate the anti-LGN antibody was added to each pellet fraction. Furthermore, an additional 100 mM, 250 mM or 500 mM NaCl was added to the P1, P2, and P3 fractions respectively. The presence of bands in lanes 2, 4, and 6, which correspond to S1, S2, and S3 respectively, indicate that LGN was successfully competed off the LGN antibody (Figure 1). Interestingly, the LGN protein detected by Western analysis appears to be around 150 kDa instead of the 76 kDa that corresponds to monomeric LGN.

Next, sonication was attempted to break open the BHK-570 tissue culture cells followed by the modified immunoprecipitation method the lab developed. After several sonication conditions were tested, it was determined that 40% amplitude and pulsing for 5 seconds on followed by 30 seconds off for a total duration of 10 seconds on resulted in the least harsh conditions to produce maximal amounts of protein in the cytosolic fraction (data not shown). When performing the modified immunoprecipitation procedure after lysing the cells using sonication in the presence of either 1 µg (left 2 lanes) or 2 µg (right 2 lanes) of peptide, it was evident that LGN protein was being competed off the LGN antibody into the supernatant fractions, lanes labeled as S1 and S2 (Figure 2). Furthermore, the sample that had 2 µg of peptide added competed about twice as much LGN into the supernatant fraction compared to the 1 µg of peptide being added (Figure 3, S2 and S1 respectively). Finally, the immunoprecipitation reaction was performed in which the presence of additional NaCl was added to the sonication buffer in BHK-570 tissue culture cells that were transfected in the presence (Figure 3 left image) or absence (Figure 3 right image) of pCMV-LGN. Interestingly, it appeared as though the BHK-570 tissue culture cells that were transfected with the pCMV-LGN plasmid resulted in more LGN being competed off the antibody, as the bands are thicker on the left Western compared to the right Western for lanes labeled S1, S2, and S3 (Figure 3). In contrast to the results obtained when using the lysis buffer to break open the cells, the amount of LGN protein competed off the antibody in the presence of 2 µg of peptide and additional 150 mM, 350 mM or 0 mM NaCl to the sonication buffer, represented by lanes labeled S1, S3, and S5 respectively, did not appear to compete off any more LGN protein (Figure 3). It is estimated that about one-third of the total LGN captured on the LGN primary antibody is being competed off into the supernatant fraction (Figure 3). The large band in the S* lane may indicate that not enough primary antibody is being added to the supernatant of the lysed cells and we are only capturing about half of the LGN being expressed from the BHK-570 tissue culture cells (Figure 3).

Discussion

LGN is known to be a crucial protein involved in cell division and mutations in LGN have resulted in several medical conditions. Although several crystal structures of the TPR motifs and GoLoco domains of LGN have been solved, there is no full-length LGN protein structure. Given that the first step of protein crystallization is to obtain 95% pure protein, it is important to be able to express and isolate functional protein before attempting to set up conditions to grow protein crystals. After it was determined that *E. coli* could not be used to overexpress LGN, BHK-570 tissue culture cells were selected based on their natural expression of LGN, suggesting that overexpression of LGN would not damage the cells or interfere with their normal function. Although it appears that the same amount of LGN is present in BHK-570 tissue culture cells transfected with and without pCMV-LGN, the amount of LGN competed off the LGN antibody using the modified immunoprecipitation procedure is higher in the BHK-570 tissue culture cells in which pCMV-LGN was added during the transfection (Figure 3). This could be due to the endogenous LGN protein having certain post-translational modifications that may not be present on the LGN expressed from the plasmid, such as phosphorylation of the T450 residue that is observed in breast cancer cell lines.[7]

Due to the potential misfolding of the LGN protein induced by the lysis buffer's detergent, sonication was utilized to allow LGN to maintain its native conformation.

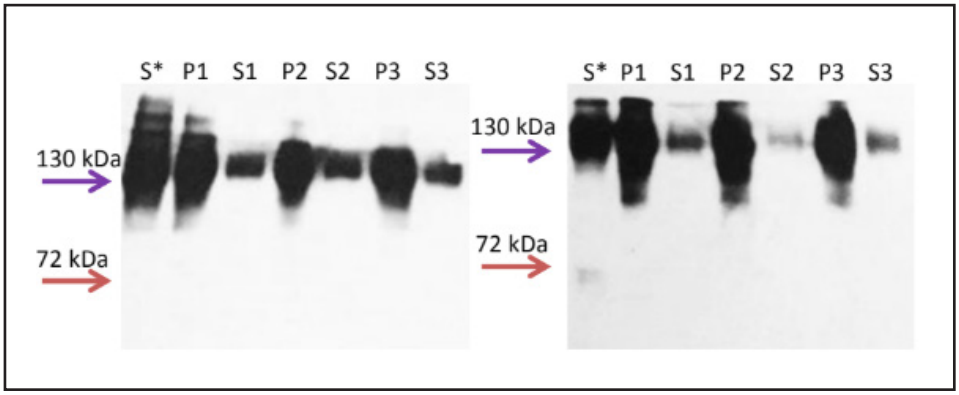

Figure 3: Isolation of LGN after sonication of the BHK-570 tissue culture cells using peptide and additional NaCl. LGN protein was released from the antibody in the presence of 2 µg of peptide and 150, 350 or 0 mM NaCl. BHK-570 tissue culture cells were transfected in the presence (left image) or absence (right image) of pCMV-LGN. Lane contents from left to right: S*, P1, S1, P2, S2, P3, S3. Orange arrow – 72 kDa; Purple arrow – 130 kDa.

Even though more LGN peptide was added during the modified immunoprecipitation procedure, the fraction of LGN present in the supernatant fractions appeared to be less than when lysis buffer was used (Figures 3 and 1, respectively). This is likely due to the detergent helping to compete LGN off the antibody.

Regardless of the way the BHK-570 tissue culture cells were broken open, the LGN bands from the Western analyses all have a significant band near 150 kDa instead of the expected 76 kDa that would correspond to monomeric LGN. Given that the TPR motifs and GoLoco domains of LGN bind, it is conceivable that dimers of LGN are forming where the TPR motifs of one protein are binding to the GoLoco domains of anther LGN protein and vice versa. Another possibility is that LGN is bound to one of its binding partners instead of dimerizing. However, this is highly unlikely because a denaturing gel was run, indicating that the interaction between the binding partners would be covalent, which is not consistent with the literature. [1,13-19] Given that each experimental condition was only run once, this data is preliminary and more experiments need to be performed to be confident that LGN is primarily at the 150 kDa band. Additionally, using an anti-LGN primary antibody that recognizes a different site than the primary antibody being used to sequester the LGN during the modified immunoprecipitation experiment and performing a functional assay to ensure that LGN can still bind to either $G\alpha_i$-GDP and/or NuMA would strengthen the possibility that LGN is being isolated as a dimer.

Given that only about one-third of the LGN is located in the supernatant fraction using the conditions tested thus far (Figure 3), the modified immunoprecipitation procedure needs to be optimized before scaling it up to obtain the amount of LGN protein necessary for screening crystallization conditions to grow protein crystals. Furthermore, the purity of the isolated LGN needs to be determined by SDS-PAGE and Coomassie blue staining. It is expected that size exclusion chromatography will be able to be utilized to obtain 95% pure LGN protein and ensure no LGN peptide is present in the final LGN fractions. Upon solving the crystal structure of the full-length, wild-type LGN, it may aid in the design of selective treatments to lessen or alleviate the symptoms experienced by patients with breast cancer, Chudley-McCullough syndrome, and/or non-syndromic hearing loss DFNB82.

Conclusion

Based on the preliminary data collected thus far, it is concluded that (i) LGN protein can be expressed in BHK-570 tissue culture cells and be isolated using a modified immunoprecipitation procedure, and (ii) more LGN protein is competed off during the modified immunoprecipitation procedure when the BHK-570 tissue culture cells are transfected in the presence of pCMV-LGN. Given that all experiments and Western data presented are representative of only one experiment, each experiment needs to be repeated at least two more times to draw firm conclusions about the data.

Acknowledgements

We would like to thank the previous students who worked on this project, many of whom worked diligently to express LGN in *E. coli* with no success: Alexander Zanetti, Michael Hyde, Benjamin Hanson, Mohammad Tarek Islam, Stephen Valentino, Hakeem Banks, Ayman Huzair, Alexandra Rosekrans, Iliana Ruiz, and Adrienne Schuler. Thank you to the Departments of Chemistry & Biochemistry, and Biology at The College at Brockport for providing lab space and equipment, and to The College at Brockport for start-up funds to purchase materials and equipment.

References

[1]Muchizuki, N., Cho, G., Wen, B., and Insel, P. (1996) "Identification and cDNA cloning of a novel human mosaic protein, LGN, based on interaction with G alpha i2." *Gene* 181.1-2. Pg 39-43.

[2]Blumer, J., Chandler, L., and Lanier, S. (2002) "Expression analysis and subcellular distribution of the two G-protein regulators AGS3 and LGN indicate distinct functionality. Localization of LGN to the midbody during cytokinesis." *Journal of Biological Chemistry* 277.18. Pg 15897-15903.

[3]Spencer, J., Darbyshire, K., Boucher, A., Kashem, M., Long, L., McGregor, I., Karl, T., and Arnold, J. (2013) "Novel molecular changes induced by Nrg1 hypomorphism and Nrg1-cannabinioid interaction in adolescence: a hippocampal proteomic study in mice." *Frontiers in Cellular Neuroscience* 7.15. Pg 1-13.

[4]Pan, Z., Zhu, J., Shang, Y., Wei, Z., Jia, M., Xia, C., Wen, W., Wang, W., and Zhang, M. (2013) "An autoinhibited conformation of LGN reveals a distinct interaction mode between GoLoco motifs and TPR motifs." *Structure* 21.6. Pg 1007-1017.

[5]Siller, K., and Doe, C. (2009) "Spindle orientation during asymmetric cell division." *Nature Cell Biology* 11.4. Pg 365-374.

[6]Woodard, G., Huang, N., Cho, H., Miki, T., Tall, G., and Kehrl, J. (2010) "Ric-8A and Giα recruit LGN, NuMA, and dynein to the cell cortex to help orient the mitotic spindle." *Molecular and Cellular Biology* 30.14. Pg 3519-3530.

[7]Fukukawa, C., Ueda, K., Nishidate, T., Katagiri, T., and Nakamura, Y. (2010) "Critical roles of LGN/GPSM2 phosphorylation by PBK/TOPK in cell division of breast cancer cells." *Genes, Chromosomes and Cancer* 49.10. Pg 861-872.

[8]Doherty, D., Chudley, A., Coghlan, G., Ishak, G., Innes, A., Lemire, E., Rogers, R., Mhanni, A., Phelps, I., Jones, S., Zhan, S., Fejes, A., Shahin, H., Kanaan, M., Akay, H., Tekin, M., FORGE Canada Consortium, Triggs-Raine, B., and Zelinski, T. (2012) "GPSM2 mutations cause the brain malformations and hearing loss in Chudley-McCullough syndrome." *The American Journal of Human Genetics* 90.6. Pg 1088-1093.

[9]Hamzeh, A., Nair, P., Mohamed, M., Saif, F., Tawfiq, N., Al-Ali, M., and Bastaki, F. (2016) "A novel nonsense GPSM2 mutation in a Yemeni family underlying Chudley-McCullough syndrome." *European Journal of Medical Genetics* 59.6-7. Pg 337-341.

[10]Mauriac, S., Hien, Y., Bird, J., Carvalho, S., Peyroutou, R., Lee, S., Moreau, M., Blanc, J., Gezer, A., Medina, C., Thoumine, O., Beer-Hammer, S., Friedman, T., Rüttiger, L., Forge, A., Nürnberg, B., Sans, N., and Montcouquiol, M. (2017) "Defective Gpsm2/$G\alpha_{i3}$ signalling disrupts stereocilia development and growth cone actin dynamics in Chudley-McCullough syndrome." *Nature Communications* 8.14907. Pg 1-17.

[11]Walsh, T., Shahin, H., Elkan-Miller, T., Lee, M., Thornton, A., Roeb, W., Abu Rayyan, A., Loulus, S., Avraham, K., King, M., and Kanaan, M. (2010) "Whole exome sequencing and homozygosity mapping identify mutation in the cell polarity protein GPSM2 as the cause of nonsyndromic hearing loss DFNB82." *The American Journal of Human Genetics* 87.1. Pg 90-94.

[12]Yariz, K., Walsh, T., Akay, H., Duman, D., Akkaynak, A., King, M., and Tekin, M. (2012) "A truncating mutation in GPSM2 is associated with recessive non-syndromic hearing loss." *Clinical Genetics* 81.3. Pg 289-293.

[13]Bowman, S., Neumüller, R., Novatchkova, M., Du, Q., and Knoblich, J. (2006) "The Drosophila NuMA Homolog Mud Regulates Spindle Orientation in Asymmetric Cell Division." *Developmental Cell* 10.6. Pg 731-742.

[14]Du, Q., Taylor, L., Compton, D., and Macara, I. (2002) "LGN blocks the ability of NuMA to bind and stabilize microtubules. A mechanism for mitotic spindle assembly regulation." *Current Biology* 12.22. Pg 1928-1933.

[15]Mapelli, M., and Gonzalez, C. (2012) "On the inscrutable role of Inscuteable: structural basis and functional implications for the competitive binding of NuMA and Inscuteable to LGN." *Open Biology* 2.8. Pg 1-9.

[16]Pan, Z., Shang, Y., Jia, M., Zhang, L., Xia, C., Zhang, M., Wang, W., and Wen, W. (2013) "Structural and biochemical characterization of the interaction between LGN and Frmpd1." *Journal of Molecular Biology* 425.6. Pg 1039-1049.

[17]Takayanagi, H., Yuzawa, S., and Sumimoto, H. (2015) "Structural basis for the recognition of the scaffold protein Frmpd4/Preso1 by the TPR domain of the adaptor protein LGN." *Acta Crystallographica Section F: Structural Biology and Crystallization Communications* 71.2. Pg 175-183.

[18]McCudden, C., Willard, F., Kimple, R., Johnston, C., Hains, M., Jones, M., and Siderovski, D. (2005) "G alpha selectivity and inhibitor function of the multiple GoLoco motif protein GPSM2/LGN." *Biochimica et Biophysica Acta* 1745.2. Pg 254-264.

[19]Kimple, R., Kimple, M., Betts, L., Sondek, J., and Siderovski, D. (2002) "Structural determinants for GoLoco-induced inhibition of nucleotide release by Galpha subunits." *Nature* 416.6883. Pg 878-881.

[20]Jia, M., Li, J., Zhu, J., Wen, W., Zhang, M., and Wang, W. (2012) "Crystal structures of the scaffolding protein LGN reveal the general mechanism by which GoLoco binding motifs inhibit the release of GDP from Gαi." *Journal of Biological Chemistry* 287.44. Pg 36766-36776.

[21]Tall, G., and Gilman, A. (2005) "Resistance to inhibitors of cholinesterase 8A catalyzes release of Galphai-GTP and nuclear mitotic apparatus protein (NuMA) from NuMA/LGN/Galphai-GDP complexes." *Proceedings of the National Academy of Sciences of the United States of America* 102.46. Pg 16584-16589.

Readability and Length of High Risk Consent Forms

By Jonathan Burns, Tracy S. Ziolek, and Karen J. Tietze
University of the Sciences

Abstract

Background: The Food and Drug Administration requires informed consent forms to be written in "language understandable to the subject." The average American reads at a 7th or 8th grade level; consent cannot be informed if the subject is unable to understand the document. Prior research analyzed specific types or sections of informed consent forms to quantify the complexity. The purpose of this study was to assess the readability and length of informed consent forms used in high-risk studies.

Methods: This study analyzed informed consent forms for high-risk clinical trials approved in 2014 by a single institution. High-risk trials were defined as Phase I trials, Phase II trials, Phase III investigator-initiated trials, and trials involving vulnerable populations (children, pregnant women, prisoners). Each informed consent form was assessed for page length and readability using the following scales: Flesch-Kincaid Grade Level (FKGL), Simple Measure of Gobbledygook (SMOG), and Flesch Reading Ease (FRE). Analyses were performed using the program Readability Studio (2015 version, Oleander Software, Ltd. Vandalia, OH).

Results: Forty-eight informed consent forms from high-risk studies were analyzed. The mean FKGL was 9.5 plus or minus 0.8 (range 7.1-11.4), indicating a 9th-10th grade education readability. Three (6.3%) of the informed consent forms were written at an 8th grade level or lower. Sixteen (33.3%) of the informed consent forms were written at a 10th grade level or higher. The mean SMOG was 11.7 plus or minus 0.7 (range 9.8-13), indicating an 11th-12th grade education readability. None of the informed consent forms were written at an 8th grade level or lower. Forty-seven (97.9%) of the informed consent forms were written at a 10th grade level or higher. The mean FRE was 55.2 plus or minus 3.6 (range 48-67), indicating the text is "fairly difficult to read." Seven (14.6%) of the informed consent forms were written at "standard difficulty" or easier. Forty-one (85.4%) of the informed consent forms were written at "fairly difficult" or harder. The mean page length was 20 plus or minus 5.2 pages (range 10-32 pages). None of the informed consent forms were shorter than 10 pages in length. Twenty-six (54.2%) of the informed consent forms were 20 pages or longer. Page length and readability were weakly correlated.

Conclusions: Informed consent forms from high-risk trials at this single academic institution were lengthy and written at a readability level higher than the desired 7th-8th grade level. The length of the informed consent forms and their difficult readability may compromise subject understanding.

Background

The United States government sets the requirements for informed consent in clinical research, which are codified in the Code of Federal Regulations (CFR). The regulations state "[N]o investigator may involve a human being as a subject in research…unless the investigator has obtained the legally effective informed consent of the subject."[1] The regulations require "[t]he information that is given to the subject or the representative shall be in language understandable to the subject or the representative."[1] However, the regulations neither define "understandable," nor establish a standard readability requirement.

In 2003 the National Center for Education Statistics (NCES) conducted a large-scale survey of over 19,000 Americans and determined that, with an average literacy score of 269 out of 500, only 12% of adults were considered to be proficient in health literacy.[2] It is estimated that the average American reads at the 7th or 8th grade level.[3] More recently, in 2012 and 2014, the Organization for Economic Cooperation and Development (OECD) conducted a similar survey and found a similar average literacy.[4] Fifty percent of respondents were classified at level 2 or below in terms of literacy (scale includes below level 1, level 1, level 2, level 3, level 4/5).[4] Level 2 requires readers to match text and information and may require low-level inferences or paraphrasing.[4] Level 3 requires readers to decipher dense text or identify, interpret or evaluate information.[4] Weighing a major decision about consenting to participate in a high-risk clinical trial may require a higher than average level of literacy.

Published studies of the readability of informed consent forms have reported on select types of research (e.g., HIV/AIDS trials, cancer trials)[5-12] and specific sections of informed consent forms.[13-14] Kass and colleagues analyzed 124 informed consent forms and templates from federally funded HIV/AIDS trials.[5] The informed consent forms were lengthy (median page length of 22.4 pages) and written at a median Flesch-Kincaid Grade Level of 9.2.[5] Looking at specifically cancer trial informed consent forms, Malik and colleagues determined an average Flesch-Kincard Grade Level of 9.8, a median Flesch Reading Ease of 55.5, and a median page length of 20 pages.[6] Meade and Howser assessed a sample of cancer trial informed consent forms and found a range of grade levels from 12 to 17.5, using the SMOG scale.[7] Using a sample from the Johns Hopkins Oncology Center, Grossman et.al. reported that readability requirements were high with a mean Flesch-Kincaid Grade Level of 11.1 ± 1.67 and a mean Flesch Reading Ease of 52.6 ± 8.7.[8] Sharp compared Flesch Reading Ease scores for informed consent forms from various sponsoring groups.[9] The Flesch Reading Ease scores were low in all groups with means ranging from 43.18 ± 3.06 for informed consent forms in the Radiation Therapy Oncology Group to 47.56 ± 5.54 for informed consent forms in the Eastern Cooperative Oncology Group.[9] Sharp reported an overall mean page length of 10.8 ± 3.9 pages and a range of 3.8 to 25.8

pages, assuming 250 words per page.[9] In a sample of cancer trial informed consent forms approved by a Canadian review board, Cheung et al. reported an average page length of 10.5, an average Flesch Reading Ease score of 61.2, and an average Flesch-Kincaid Grade Level of 7.4.[10] Nair and colleagues compared 140 industry sponsored and non-industry sponsored informed consent forms.[11] Although both types of consent forms were written at a high grade level, the non-industry sponsored informed consent forms were written at a higher grade level than the industry sponsored informed consent forms (mean Flesch-Kincaid Grade Level 12.2 ± 1.3 vs. 9.7 ± 0.7, respectively, p-value <0.001 and mean Flesch Reading Ease 38.5 ± 8.0 vs. 48.9 ± 4.8, respectively, p-value<0.001).[11] In a study of 88 emergency department informed consent forms, informed consent forms from high-risk studies were longer and more complex than informed consent forms from moderate- or low-risk studies with significantly higher grade level readability (11.0 ± 1.2, 10.1 ± 1.7, 9.1 ± 2.6, respectively; p=0.03).[12] Informed consent forms from the high-risk studies were more detailed and contained longer and more complex sentences.[12]

Specific sections of informed consent forms have been assessed for readability. Larson and colleagues assessed the methods sections of 100 informed consent forms from various specialties.[13] The average Flesch Kincaid Grade Levels ranged from 10.5 for the pediatric informed consent forms to 13.1 for the surgical informed consent forms.[13] Tarnowski and colleagues assessed one hundred word sections from 238 informed consent forms.[14] The overall mean Flesch Reading Ease score was 26.9 ± 8.77 ("confusing"; understandable by college graduates).[14] They reported that the description of the experimental procedures had the best reading score (mean Flesch Reading Ease 42.88 ± 7.49) and that the description of the informed consent statement had the worst reading score (mean Flesch Reading Ease 21.96 ± 0.54).[14]

Readability of informed consent forms goes beyond just the intrinsic reading level of the words themselves; the page length of the document plays an important role as well. Dresden and Levitt compared a standard pharmaceutical industry longer informed consent form and a modified shorter informed consent form with the minimum required information and formatting modifications such as shortened headings and bullets.[15] The Flesch-Kincaid Grade Levels of the standard and modified informed consent forms were grade 12 and grade 8.7, respectively.[15] Thirty-two percent of subjects admitted to not reading the standard longer form compared to one subject (2%) who admitted to not reading the modified form.[15] Sharp recommends that an informed consent form should be no longer than 1250 words or 5 pages, as previous research established that a person is less likely to read an informed consent form if it is over 1000 words or 4 pages.[9] The importance of length was noted in 1969 when Epstein observed that comprehension decreased as length of informed consent forms increased.[16]

Little is known about the readability of informed consent forms for high-risk clinical studies. High-risk clinical trials are often complex, suggesting that informed consent forms for these trials may be lengthy and difficult to understand. The purpose of this descriptive study was to determine the readability and length of informed consent forms used in high-risk trials at a single academic institution.

Methods

Materials

Informed consent forms from high-risk clinical trials initially approved in 2014 by one of eight institutional review boards at the University of Pennsylvania were included in this study. "High-risk" was defined as Phase I trials, Phase II trials, investigator-initiated randomized Phase III trials, and trials involving the vulnerable populations of prisoners, children, pregnant women, human fetuses, or neonates. High-risk trials involving gene therapy or gene transfer were excluded due to the inability to anonymize the informed consent forms.

Oversight

The study protocol was reviewed by the Office of Regulatory Affairs, which determined that regulatory oversight was not required.

Methodology

An administrator from the institution's Office of Regulatory Affairs identified the high-risk protocols. The administrator removed identifying information from the informed consent forms (names of investigators, investigator contact information, and study sponsors) and forwarded the anonymized informed consent forms to the investigators as digital files.

The informed consent forms were assessed using three readability scales from Readability Studio software (version 2015, published August 9, 2015 by Oleander Software, Ltd., copyright 2015, Vandalia, Ohio): Flesch-Kincaid Grade Level, Simple Measure of Gobbledygook, and Flesch Reading Ease. The Flesch-Kincaid Grade Level (FKGL) was calculated as [11.8 × (average syllables per word)] + [0.39 × (average words per sentence)] - 15.59. The Simple Measure of Gobbledygook (SMOG) was calculated as 1.0430 × √(number of words with ≥3 syllables) + 3.1291. The FKGL and SMOG scores identified the document's grade reading level. The Flesch Reading Ease (FRE) was calculated as 206.835 - [84.6 × (average syllables per word)] - [1.015 × (average words per sentence)]. The FRE calculated a score of zero to one hundred, with higher numbers denoting an easier to understand document (90-100: very easy; 80-89: easy; 70-79: fairly easy; 60-69: standard; 50-59: fairly difficult; 30-49: difficult; 0-29: very confusing).

An investigator (JB) manually counted the number of pages in each informed consent form beginning with the title page and ending with the page including the patient's signature; appendices, if present, were excluded.

Objectives

The primary objective of this study was to determine the readability of informed consent forms used in high-risk trials at the University of Pennsylvania as measured by Flesch-Kincaid Grade Level, Simple Measure of Gobbledygook, Flesch Reading Ease and page length. A secondary objective of this study was to explore the relationships between each readability score and page length.

Statistical analysis

Descriptive statistics (mean, standard deviation, median, range) were performed for Flesch-Kincaid Grade Level, Simple Measure of Gobbledygook, Flesch Reading Ease and number of pages using StatPlus:mac LE (version 6.0.3, published 2016 by AnalystSoft Inc., copyright 2016, Walnut, CA). Correlative statistics for readability score and page length were performed using Microsoft Excel for Mac 2011 (version 14.6.2, published 2016 by Microsoft Corporation, copyright 2010, Redmond, WA).

Results

The sample consisted of 48 high-risk study informed consent forms. Thirty-six of the informed consent forms (75%) were from oncology trials. Five of the informed consent forms (10.4%) were from HIV/AIDS trials. Three of the informed consent forms (6.3%) were from non-HIV infectious disease trials. The remaining 4 informed consent forms (8.3%) were from other types of trials including one pediatric trial. Eighteen of the informed consent forms (37.5%) were for Phase I trials. Sixteen of the informed consent forms (33.3%) were for Phase II trials. Seven of the informed consent forms (14.6%) were for Phase I/II

trials. One informed consent form (2.1%) was for a Phase I/III trial and one informed consent form (2.1%) was for a Phase II/III trial. Phases were not identifiable for five (10.4%) of the informed consent forms.

The mean FKGL was 9.5 ± 0.8 (range 7.1-11.4) (Table 1). Three (6.3%) informed consent forms had a required reading level within 7th grade (7.0-7.9). Five (10.4%) informed consent forms had a required reading level within 8th grade (8.0-8.9). Twenty-four (50%) informed consent forms had a required reading level within 9th grade (9.0-9.9). Fifteen (31.3%) informed consent forms had a required reading level within 10th grade (10.0-10.9). One (2.1%) informed consent form had a required reading level within 11th grade (11.0-11.9) (Figure 1(a)). Three (6.3%) of the 48 informed consent forms were written at an 8th grade level or below. Sixteen (33.3%) of the 48 informed consent forms were written at a 10th grade level or above.

The mean SMOG score was 11.7 ± 0.7 (range 9.8-13) (Table 1). One (2.1%) informed consent form had a required reading level within 9th grade (9.0-9.9). Four (8.3%) informed consent forms had a required reading level within 10th grade (10.0-10.9). Twenty-four (50%) informed consent forms had a required reading level within 11th grade (11.0-11.9). Eighteen (37.5%) informed consent forms had a required reading level within 12th grade (12.0-12.9). One (2.1%) informed consent form had a required reading level within the first year of college (13.0-13.9) (Figure 1(b)). None of the informed consent forms were written at an 8th grade level or lower. Forty-seven (97.9%) of the 48 informed consents forms were written at a 10th grade level or higher.

The mean FRE score was 55.2 ± 3.6 (range 48-67) (Table 1). Seven (14.6%) of the informed consent forms were considered to have standard readability (60-69). Thirty-nine (81.3%) of the informed consent forms were considered to have fairly difficult readability (50-59). Two (4.2%) of the informed consent forms were considered to have difficult readability (30-49) (Figure 1(c)).

The mean page length was 20 ± 5.2 (range 10-32) (Table 1). Seven (14.6%) of the informed consent forms had a length of 10-14 pages. Fifteen (31.3%) of the informed consent forms had a length of 15-19 pages. Seventeen (35.4%) of the informed consent forms had a length of 20-24 pages. Eight (16.7%) of the informed consent forms had a length of 25-29 pages. One (2.1%) informed consent form had a length of 30-35 pages (Figure 2). None of the informed consent forms were shorter than 10 pages in length. Twenty-six (54.2%) of the informed consent forms were 20 pages or longer.

Table 1: Grade Level, Reading Ease, and Page Length Results

Parameter	Mean ± SD	Median	Range
FKGL[a]	9.5 ± 0.8	9.55	7.1-11.4
SMOG[b]	11.7 ± 0.7	11.8	9.8-13
FRE[c]	55.2 ± 3.6	55	48-67
Page Length	20 ± 5.2	20	10-32

a. FKGL: Flesch-Kincaid Grade Level
b. SMOG: Simple Measure of Gobbledygook
c. FRE: Flesch Reading Ease

The average words per sentence from each informed consent form ranged between 8 and 23 words per sentence. The average syllables per words from each informed consent form ranged between 1.5 and 1.7 syllables per word. The relationship among FRE score, average syllables per word, and average words per sentence are shown in Figure 3.

The correlation between page length and FKGL was weakly negative (r = -0.3551). The correlation between page length and SMOG was weakly negative (r = -0.4264). The correlation between page length and FRE was weakly positive (r = 0.4068).

Discussion

These results indicate that the high-risk study informed consent forms were written at a level higher than the average American's 7th to 8th grade readability level. The FKGL scores indicate that a potential study participant needs a late elementary school to late high school education to read and understand the informed consent forms. The SMOG scores indicate that a potential study participant needs an early high school to early college education to understand the informed consent forms. The FRE scores indicate that a potential study participant needs to be able to understand at least "standard" readability. These expectations may be unrealistic for the range of potential study participants in high-risk clinical trials.

These study results are consistent with previously published informed consent form readability studies. Problems with informed consent form readability affect most, if not all, clinical research. High-risk studies often involve complex procedures and complicated risks associated with early phase investigational agents, leading to lengthy and highly detailed informed consent forms. Sacks and Warren expressed concern over increasingly dense informed consent forms.[17] They noted that, "Informed-consent documents may balloon beyond their already unreadable lengths. Such over-disclosure can easily become nondisclosure, if information about important possible harms and

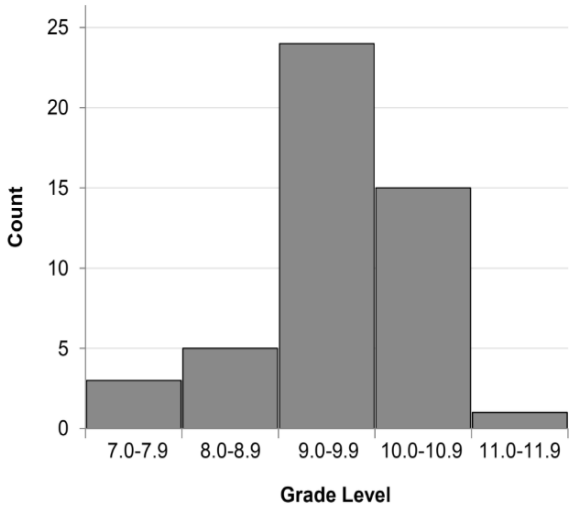

Figure 1(a) Flesch-Kincaid Grade Level: Distribution of informed consent forms by Flesch Kincaid Grade Level readability score; scores correspond to grade level.

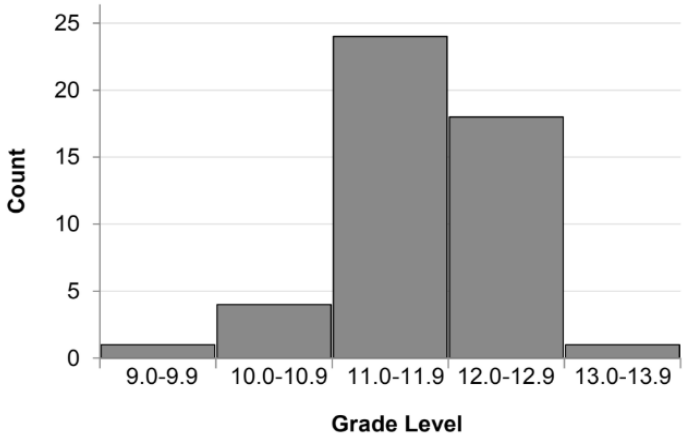

Figure 1(b) Simple Measure of Gobbledygook: Distribution of informed consent forms by Simple Measure of Gobbledygook readability score; scores correspond to grade level.

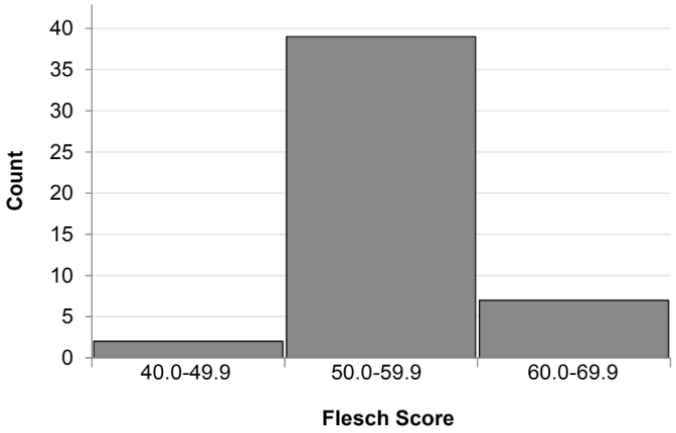

Figure 1(c) Flesch Reading Ease: Distribution of informed consent forms by Flesch Reading Ease readability score. Scores correspond as follows: 40-49 for difficult, 50-59 for fairly difficult, and 60-69 for standard readability.

benefits gets buried in voluminous legalistic text."[17] Grady noted that "...decisions are driven more by trust in their doctors or by deference to authority than by the information provided."[18]

In September 2015 the U.S. Department of Health and Human Services released a Notice of Proposed Rulemaking (NPRM) detailing proposed regulatory changes that will affect the informed consent process.[19] The proposed changes would streamline the process and modify the informed consent form to include only information that a "reasonable" person would wish to know; other information could be included in unrestricted supplemental content.[19] One important change is that consent forms would need to be made briefer; however, no specific limitation was named. The NPRM would also require public posting of clinical trial consent forms, which would open up informed consent forms to public scrutiny.[19] The Department of Health and Human Services invited comments from the public but no final decree has come out yet.

Similar results from multiple validated scoring systems increase the validity of the assessments. Finally, the unique approach of this study in assessing high-risk trials of all kinds, not just one discipline of trials, suggests that the readability problem is common to the entire population of high-risk trials.

Study limitations include the single institution sample and limitations of the validated scoring systems. Only one year of consent forms were analyzed; it would be valuable to look at a larger sample over multiple years to rule out any chance that the sample year was a unique year. Additionally, expanding the sample to include other institutions would provide more information about the generalizability of the study results. Also important to note, is an intrinsic limitation of readability scales; they can account only for word length and sentence length. There is no scale available that can account for a word's definition. A short word with a "hard" definition would score better than a long word with an "easy" definition. Scales other than SMOG also score documents on partial comprehension whereas SMOG scores based on complete comprehension, which is why SMOG grade levels are generally higher than FKGL scores.[20] SMOG may therefore overestimate a document's complexity, while FKGL may underestimate a document's complexity. Additionally, none of the assessment scales are designed specifically for health-care related information. FKGL was designed to score technical manuals and documents[21] and FRE was designed for analyzing academic textbooks and manuals.[22]

Conclusion

Readability of informed consent forms from high-risk studies at this academic medical center was higher than

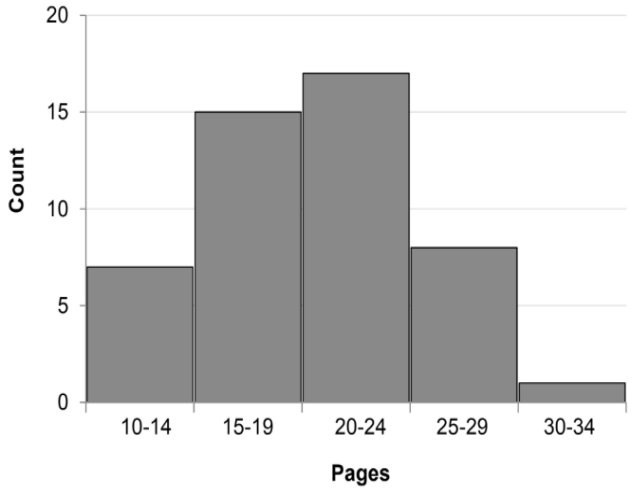

Figure 2 Page Length Distribution: Distribution of informed consent forms by length in pages.

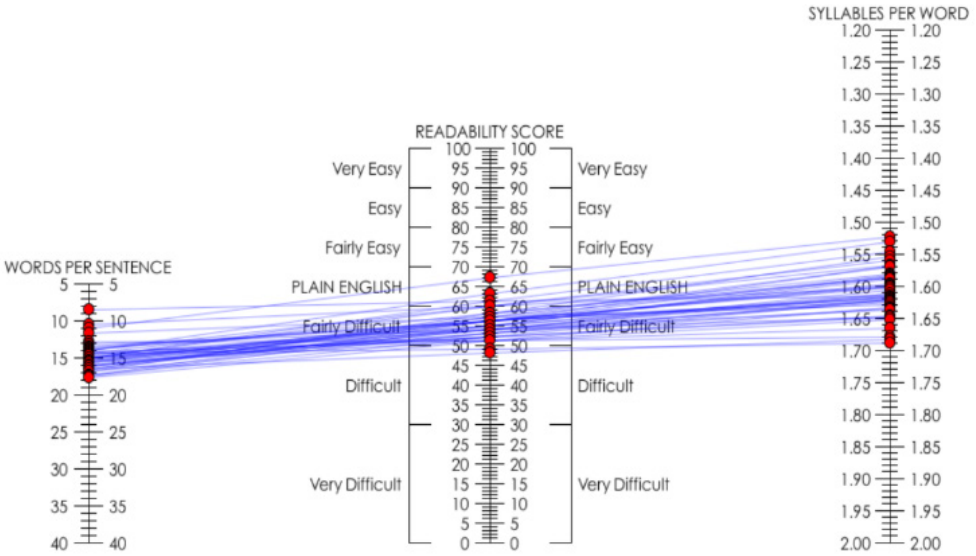

Figure 3. Flesch Reading Ease Results: Relationship between average words per sentence, Flesch Reading Ease score, and average syllables per word.

the desired 7th to 8th grade reading level. The mean page length was an intimidating 20 pages; none of the informed consent forms were shorter than ten pages. Subject understanding is likely compromised by the high grade readability level and large number of pages.

Acknowledgements

We thank David Heagerty for de-identifying the informed consent forms analyzed in this study.

References

[1]General requirements for informed consent, 21 C.F.R. Sect. 50.20 (2015).

[2]Kutner M, Greenberg E, Jin Y, and Paulsen C. (2006) *The Health Literacy of America's Adults: Results From the 2003 National Assessment of Adult Literacy* .U.S.Department of Education.Washington, DC: National Center for Education Statistics.

[3]Walsh TM and Volsko TA. (2008) "Readability assessment of internet-based consumer health information." *Respiratory Care*. 53.10. Pg 1310-1315.

[4]Rampey BD, Finnegan R, Goodman M, Mohadjer L, Krenzke T, Hogan J, and Provasnik S. (2016). *Skills of U.S. Unemployed, Young, and Older Adults in Sharper Focus: Results From the Program for the International Assessment of Adult Competencies (PIAAC) 2012/2014: First Look*. U.S. Department of Education. Washington, DC: National Center for Education Statistics

[5]Kass NE, Chaisson L, Taylor HA, and Lohse J. (2011) "Length and complexity of US and international HIV consent forms from federal HIV network trials." *Journal of General Internal Medicine.* 26.11. Pg 1324-1328.

[6]Malik L, Kuo J, Yip D, and Mejia A. (2014) "How well informed is the informed consent for cancer clinical trials?" *Clinical Trials.* 11.6. Pg 686-688.

[7]Meade CD and Howser DM. (1992) "Consent forms: how to determine and improve their readability." *Oncologyl Nursing Forum*. 19.10. Pg 1523-1528.

[8]Grossman SA, Piantadosi S, and Covahey C. (1994) "Are informed consent forms that describe clinical oncology research protocols readable by most patients and their families?" *Journal of Clinical Oncology*. 12.10. Pg 2211-2215.

[9]Sharp SM. (2004) "Consent documents for oncology trials: does anybody read these things?" *American Journal of Clinical Oncology*. 27.6. Pg 570-575.

[10]Cheung WY, Pond GR, Heslegrave RJ, Enright K, Potanina L, and Siu LL. (2010) "The contents and readability of informed consent forms for oncology clinical trials." *American Journal of Clinical Oncology.* 33.4. Pg 387-392.

[11]Nair SC and Ibrahim H. (2015) "GCP compliance and readability of informed consent forms from an emerging hub for clinical trials." *Perspectives in Clinical Research.* 6.2. Pg 104-108.

[12]Mader TJ and Playe SJ. (1997) "Emergency medicine research consent form readability assessment." *Annals of Emergency Medicine.* 29.4. Pg 534-539.

[13]Larson E, Foe G, and Lally R. (2015) "Reading Level and Length of Written Research Consent Forms." *Clinical and Translational Science.* 8.4. Pg 355-356.

[14]Tarnowski KJ, Allen DM, Mayhall C, and Kelly PA. (1990) "Readability of pediatric biomedical research informed consent forms." *Pediatrics.* 85.1. Pg 58-62.

[15]Dresden GM and Levitt MA. (2011) "Modifying a standard industry clinical trial consent form improves patient information retention as part of the informed consent process." *Academic Emergency Medicine.* 8.3. Pg 246-252.

[16]Epstein LC and Lasagna L. (1969) "Obtaining informed consent. Form or substance." *Archives of Internal Medicine.* 123.6. Pg 682-688.

[17]Sacks CA and Warren CE. (2015) "Foreseeable risks? Informed consent for studies within the standard of care." *New England Journal of Medicine.* 372.4. Pg 306-307.

[18]Grady C. (2015) "Enduring and emerging challenges of informed consent." *New England Journal of Medicine.* 372.9. Pg 855-862.

[19]Department of Health and Human Services (US). (2015) "Federal policy for the protection of human subjects; proposed rules." *Federal Register.* 80.173. Pg 53936.

[20]McLaughlin H. (1969) "SMOG grading - a new readability formula." *Journal of Reading*. 22, Pg 639-646.

[21]Kincaid JP, Fishburne RP, Rogers RL, and Chissom BS. *Derivation of New Readability Formulas (Automated Readability Index, Fog Count and Flesch Reading Ease Formula) for Navy Enlisted Personnel.* Millington: Naval Technical Training Command, 1975.

[22]Flesch RF. *How to Write Plain English: a Book for Lawyers and Consumers.* New York: Harper & Row, 1979.

An Evaluation of Some Herbal Medicines Used in the Treatment of Typhoid Fever

By Mordecai James
Ahmadu Bello University

Abstract

This study examined the antibacterial activity of five indigenous herbal preparations used in the treatment of typhoid fever. Five herbal remedies (coded S1–S5) indicated for the treatment of typhoid fever were purchased from various outlets of the herbal producers in Zaria, Kaduna State, and Nigeria, and were screened for their activities against clinical isolates of Salmonella Typhi using the agar well diffusion method. The conventional antibiotic, ciprofloxacin, was used as a comparative standard. On completion of the screenings, none of the herbal medicines showed any antibacterial activity against the test organism. Ciprofloxacin (20µg/mL) showed antibacterial activity on the test organism as it had a clear zone of inhibition of the growth of the test organism with a mean diameter of 40mm. The inactivity of the herbal medicines used in this study indicates that they may have limited value in the treatment of typhoid fever.

Background

Typhoid fever is a common worldwide bacterial disease transmitted by the ingestion of food or water contaminated with the faeces of an infected person, which contain the bacterium *Salmonella enterica* subspecies *enterica* serotype Typhi.[1] The infection is characterized by symptoms such as fever, diarrhoea, vomiting, abdominal pain, headache, splenomegaly, anorexia, and hepatomegaly.

Worldwide, an estimated 21.7 million cases of typhoid fever and about 190,000 deaths, occur yearly, mostly in developing countries.[2] Despite advances in public health and hygiene, the disease remains endemic in many developing countries. This has led to the heavy reliance on traditional treatment of the infection with the use of medicinal plants in these countries. According to reports by the World Health Organization (WHO), 80% of the world's population, especially rural people living in developing countries, rely mainly on traditional therapy, involving plant extracts or active plant substances.[3] WHO also reported that in Nigeria, the ratio of traditional medicine practitioners to the population was 1:110, while the ratio of conventional medical doctors to the population was 1:16,400, leading to high patronage of herbal medicine practitioners.[4] In addition to lack of access, the high costs of conventional antibiotics limit their availability and use.[5] However, most of the herbal product developers often claim that their products can cure all forms of ailments. There is a need to authenticate these claims as a basis for the safe and correct use of plant-based natural health products. Assurances of safety, efficacy and quality of herbal medicines have been limited by a lack of extensive research and inadequate regulation and registration of herbal medicines.[6, 7]

The use of herbal medicine in the treatment of disease is a therapeutic modality which has a long history and has stood the test of time.[8] In recent studies, some herbal remedies have been found to have a broad spectrum of antimicrobial activities against pathogenic organisms while others were found to have little inhibitory effect on microbes.

Oyetayo assessed the microbial quality and antibacterial properties of two Nigerian herbal remedies that claimed to cure all manners of microbial diseases.[9] The result of his work showed that although the herbal preparations were found to contain some important phytochemicals, such as saponin, tannins, alkaloids, anthraquinone, and cardiac glycosides, they were contaminated with the following microorganisms: *Bacillus subtilis, Bacillus coagulans, Bacillus cereus, Basidiobotrytis* species, *Oedocephalum* species, *Varicosporium* species, and *Articulospora inflata*. Antibacterial analysis using agar well diffusion and killing rate methods revealed that the herbal remedies had bacteriostatic and not bactericidal effects. The herbal remedies did not show any sign of inhibition of the indicator bacteria when the agar diffusion method was used. However, using the rate of killing, the herbal preparations showed bacteriostatic effects on the indicator bacteria as growth rate decreased from the first hour to the fifth hour. The presences of microbial contaminants in the herbal remedies also suggest that they may serve as a source of infection to end users.[9]

Nwankwo et al. investigated the antibacterial activities of ten different traditionally made herbal concoctions collected from herbal medicine practitioners at the traditional medical trade fare in Imo State of Nigeria.[10] From the screening experiments, it was reported that only four products showed antibacterial activity, two inhibited the growth of *Escherichia coli* (mean zone of inhibition of 16.75mm), one was effective against *Staphylococcus aeurus* (mean zone of inhibition of 26.45mm), and the other slightly inhibited the growth of *Pseudomonas aeruginosa* (mean zone of inhibition of 3.78mm).[10]

The aim of this present study was to evaluate the efficacy of five Nigerian-produced anti-typhoid herbal preparations.

Materials and Methods

Study area

Zaria is a major city in Kaduna State in Northern Nigeria. Formerly known as Zazzau, it was one of the original seven Hausa city-states. It is located between 11°04`N 7°42`E and 11°67`N 7°70`E. The 2006 Census placed the population of Zaria at 408,198. Zaria covers a total area of 300 km² (100 sq mi).[11]

The sale and use of herbal remedies is a common practice in Zaria. It is a common sight to see herbal retailers hawking their products and, more recently, mobile retailers selling their products from moving vehicles fitted with sound equipment used for advertising their herbal preparations. There have also been an increasing number of herbal medicine outlets and centres in plazas and shopping malls, some of which even produce pamphlets advertising their products. People with various ailments ranging from typhoid fever to certain sexually transmitted diseases patronize these herbal medicine practitioners for an

assortment of herbal preparations with claim to be effective against their medical conditions.

Laboratory Studies

Location of experiment

The laboratory work was conducted at the Parasitological Laboratory of the Department of Microbiology, Ahmadu Bello University, Zaria. The experiment was carried out from May to August, 2015.

Sources of experimental materials

Clinical isolates of the test organism, *Salmonella* Typhi were obtained from a stock culture of the Department of Microbiology.

The antibiotic ciprofloxacin was obtained from a pharmaceutical outlet and the media were bought from a laboratory equipment sales outlet in GRA community of Zaria.

Packets and bottles of herbal products indicated for the treatment of typhoid fever were bought from five randomly selected local vendors and retailers within GRA and Sabon Gari communities. Three of the products were in the form of powders, one was capsular in nature, and the other was liquid. They were labelled with the codes (S1-S5, respectively) by the researcher (Table 1).

Experimental Design

Media preparation

Mueller Hinton agar was prepared according to the manufacturer's instructions. 9.5g of agar were mixed with 250ml of distilled water in a conical flask, the solution was heated with continuous stirring until it reached boiling point, and was allowed to boil for one minute. The heated solution was then autoclaved at 121°C for 15 minutes.[12]

After the solution was autoclaved, it was allowed to cool, and was then dispensed into 11 sterile Petri dishes. The dispensed solutions in Petri dishes were allowed to completely cool and set. The dishes were then placed in an oven for five minutes to remove excess moisture.

Seeding of the media

The prepared media was seeded with *Salmonella enterica* serotype Typhi. A colony of the pure culture of *Salmonella* Typhi was suspended in 10ml of sterile, saline water; the suspension was standardized with a 0.5 McFarland solution. About 2ml of the standard suspension was poured into each Petri dish; a sterile swab stick was used to spread the suspension across the prepared media.[9]

Introduction of varying concentrations of the herbal preparations into the media

A 7mm sterile cork borer was used to make holes on the seeded media. Five holes were bored in each plated media and labelled accordingly. Each of the five different concentrations was placed in each of the holes. The suspensions of herbal medicines in the seeded media were allowed to stand for an hour before they were placed in an incubator (at 37°C), where they were left for 24 hours.

Preparation of the control plate

The eleventh seeded plate was not bored with a cork borer. A ciprofloxacin disc (20µg/mL) was placed on the seeded Petri dish and then transferred into an incubator and incubated at 37°C. This plate served as a positive control for the experiment.

The experiment was conducted in batches of four (A-D).

Batch A experiment. In this batch, the experiment was done to investigate the activity of the herbal products with concentrations indicated by the manufacturers.

Five different concentrations of the herbal products (as shown below) were made as indicated for use by the manufacturers.

The stock concentrations were made following the manufacturer's instructions, from which serial dilutions were made.

Product S1. A teaspoon of Product S1 weighing 10.30g was mixed with 250ml of sterile distilled water to give a concentration of 41.20mg/ml. From this, a serial dilution of the 41.20mg/ml solution was made to have the following dilutions: 20.60mg/ml, 10.30mg/ml, 5.15mg/ml, and 2.58mg/ml.

Product S2. A teaspoon of Product S2 weighing 8.40g was mixed with 250ml of sterile distilled water to give a concentration of 33.60mg/ml. From this, a serial dilution of the 33.60mg/ml solution was made to have the following dilutions: 16.80mg/ml, 8.40mg/ml, 4.20mg/ml, and 2.10mg/ml.

Product S3. A teaspoon of Product S3 weighing 6.50g was mixed with 250ml of sterile distilled water to give a concentration of 26.00mg/ml. From this, a serial dilution of the 26.00mg/ml solution was made to have the following dilutions: 13.00mg/ml, 6.50mg/ml, 3.25mg/ml, and 1.63mg/ml.

Product S4. The content of two capsules of Product S4 weighing 6.50g was mixed with 250ml of sterile distilled water to give a concentration of 26.00mg/ml. From this, a serial dilution of the 26.00mg/ml solution was made to have the following dilutions: 13.00mg/ml, 6.50mg/ml, 3.25mg/ml, and 1.63mg/ml.

Product S5. Four teaspoons full of Product S5 were taken as original stock from which serial dilutions of the original solution was made to give the following dilutions: 100%, 50%, 25%, 12.50%, and 6.25%.

These different concentrations of each of the herbal products were tested for sensitivity against the test organism following the procedure stated above.

Batch B experiment. In this batch, the manufacturers' instructions were disregarded for a more scientific approach. Five different concentrations of the herbal products (as shown below) were made following standard scientific procedures.

The stock concentration was made by weighing 1g of the medicines and dissolving it in 10ml of sterile distilled water to give a concentration of 100mg/ml. From this, a serial dilution of the 100mg/ml solution was made to give the following dilutions: 50mg/ml, 25mg/ml, 12.5mg/ml, and 6.25mg/ml.

For Product S5 (a liquid), the stock concentration was made by mixing 1ml of the herbal medicine with 9ml of sterile distilled water to give a concentration of 10%. From this, a serial dilution of the 10% solution was made to give the following dilutions: 5%, 2.5%, 1.25%, and 0.625%.

Product Code	Indication(s)	Nature	NAFDAC Reg. No.
S1	Typhoid	Powder	Absent
S2	Typhoid	Powder	Present
S3	Typhoid	Powder	Present
S4	Typhoid	Capsule	Absent
S5	All Infections	Liquid	Present

Table 1: Products and their therapeutic claims

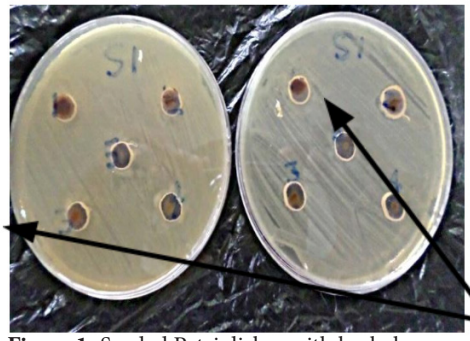

Figure 1: Seeded Petri dishes with herbal suspensions.

Figure 2: Control plate with ciprofloxacin.

These different concentrations of each of the herbal products were tested for sensitivity against the test organism following the procedure stated above.

Batch C experiment. Batch C was done to accommodate the fact that most herbal medicines are slow in activity and require longer time than orthodox medications to show any noticeable results. The methods of preparation of varying concentrations of herbal medicines, media, control plates and the seeding of media were as in Batch B. However, the period of incubation of the seeded media was prolonged to 72 hours instead of 24 hours to allow for increased residence time.

The suspensions of herbal medicines in the seeded media were allowed to stand for an hour before they were placed in an incubator, where they were incubated at 37°C for 72 hours and watched in intervals of 24 hours for a zone of inhibition.

Batch D experiment. This batch took into consideration the possibility of activity of the herbal products by cumulative effects. The methods of preparation of varying concentrations of herbal medicines, media, control plates, and the seeding of media were as in Batch B. However, the introductions of varying concentrations of the herbal products into the agar wells were done in four series. The first series of introductions was done during the initial preparation of the media. The second, third, and fourth series were done after incubating the plates at 37°C for 24, 48, and 72 hours respectively.

Batches of Experiment	Diameter of Zone of Inhibition (mm)
Batch A	39.5
Batch B	38.5
Batch C	41.5
Batch D	40.5
Mean: 40 **Standard Deviation:** 1.12	

Table 2: Susceptibility of test organism to ciprofloxin (20µg/mL).

Results

The result of the sensitivity test conducted showed that none of the herbal products showed any sign of inhibition of *Salmonella* Typhi as there was no zone of inhibition in each of the agar wells for each of the herbal products.

It was also observed that the test organisms were susceptible to the standard antibiotic Ciprofloxacin (20µg/mL), with a mean zone of inhibition of 40mm and a standard deviation of 1.12 (Table 2).

Discussion

The results of this study show that all of the five herbal products tested for efficacy against Salmonella Typhi had no antibacterial effects against the bacteria. This means these products do not inhibit the growth of the test organism and, therefore, may have no value in the treatment of typhoid fever as claimed. Similar observations were made by Oyetayo (2008), who reported that the claims by the manufacturers that their products were complete antimicrobial remedies (99.9%) was not true; rather, the products had bacteriostatic and not bactericidal effects.[9]

The failure of these herbal remedies to exert antibacterial effects on the test organism may not be enough to conclude that they do not contain substances that can exert antibacterial activity against the test organisms. This is because the potency of these herbal remedies depends on their method of production.[13]

The antibiotic Ciprofloxacin had inhibitory activities at therapeutic concentrations when compared with that of the herbal products. The comparison of the activity of the herbal remedies with conventional antibiotics showed that conventional antibiotics are more active than herbal preparations.[13]

Recommendations

It is recommended that herbal medicine practitioners should be educated on the need to get appropriate concentrations of the bioactive components in plants instead of merely using the whole infusion. Also, it is strongly advocated that drug regulatory agencies should pay closer attention to the authentication of the pharmacological claims of these herbal medicines sold in Nigeria. In addition, further research on the claims, content, and mode of action of herbal remedies are required.

References

[1]Todar, K. (2008) *A Textbook of Bacteriology*. New York: Madison Publishers. Pg 21-37.

[2]Lozano, R., Naghavi, M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., Abraham, J., Adair, T., Aggarwal, R. and Ahn, Y. (2012) "Global and Regional Mortality from 235 Causes of Death for 20 Age Groups in 1990 and 2010: A Systematic Analysis for the Global Burden of Disease Study 2010." *International Journal of Infectious Disease*. 380(9859). Pg 2095-2128.

[3]World Health Organization. (2002) "Traditional Medicine Strategy 2002-2005." World Health Organization: Geneva.

[4]African Health Monitor. (Jan.-Jun. 2003). "Traditional Medicine: Our Culture, Our Future." *African Health Monitor*. 4.1.

[5]Hack, S. (2005) "Do Not Put Too Much Value On Conventional Medicine." *Journal of Ethnopharmacology*. 100. Pg 37-39.

[6]Pietroni, P. (1992) "Beyond the Boundaries: Relationship Between General Practice and Complementary Medicine." *The BMJ*. 305. Pg 33-43

[7]World Health Organization. (1999) "Quality Control Methods for Medicinal Plant Materials." World Health Organization: Geneva.

[8]Anwannil, H. and Atta, R. (2006) "Trends in

Ethnopharmacology." *Journal of Ethnopharmacology*. 100. Pg 43-49.

[9]Oyetayo, V. (2008) "Microbial Load and Antimicrobial Property of Two Nigerian Herbal Remedies." *African Journal of Traditional, Complementary and Alternative Medicine.* 5.1. Pg 74 – 78.

[10]Nwankwo, I., Abbey, S. and Achi O. (2013) "Antibacterial Activities of Some Commercially Available Herbal Remedies in Owerri, Imo State." *Journal of Natural Sciences Research.* 2.10. Pg 79-81.

[11] Gihring, T. (1984) "Intraurban Activity Patterns among Entrepreneurs in a West African Setting". *Geografiska Annaler. Series B, Human Geography.* **66** (1): 19-20.

[12]Bauer, A., Kirby, W., Sherris, J. and Turck, M. (1966) "Antibiotic Susceptibility Testing by a Standardized Single Disc Method." *American Journal of Clinical Pathology*. 45. Pg 493-496.

[13]Anibijuwon, I., Duyilemi, O. and Onifade, A. (2010) "Antimicrobial Activity of Leaf of *Aspilia africana* on some Pathogenic Organisms of Clinical Origin." *Ethnobotanical Leaflets.* 14. Pg 390-401.

Outdoor Recreation Motivations and Constraints of South Dakota Residents

By Paige E. O'Farrell, B.S., and Hung-Ling (Stella) Liu, Ph.D.
South Dakota State University

Abstract

Understanding participants' motivations and barriers towards recreation is essential for outdoor recreation providers to create a desirable leisure experience for users. The purpose of this study is to use residents of the state of South Dakota as the target population for understanding the local residents' motivation and constraints in outdoor recreation and to investigate the relationship between motivation and constraints in outdoor recreation. This research project was a collaboration between South Dakota Department of Game, Fish, and Parks (GFP) and South Dakota State University through an online survey platform in the fall of 2017 as a part of a broader outdoor recreation research project for the state. The results indicated: (1) the residents in South Dakota who participate in outdoor recreation were highly driven by internal motivations; (2) the leisure constraints of South Dakota's residents were similar to those found in a national study; (3) there was a significant, but weak correlation between recreation motivation and leisure constraints. Future studies might focus on specialized outdoor recreation users or non-participants to further the understanding of the needs and barriers to enjoying the outdoors.

Introduction

Understanding participants' motivations and barriers to recreation is essential for outdoor recreation providers to create a desirable leisure experience for users.[1,2] Outdoor recreation is one of the most prevalent leisure choices; motivation for participation in outdoor recreation has been a central concern in this field to determine why and how people engage and behave in leisure time and to understand the consequences of leisure involvements.[3] Leisure constraints are also an important construct in understanding the factors that limit people's participation in leisure activities, services, and current enjoyment. Although the relationship between motivation and leisure constraints has been discussed in literature to explain the negotiation process of involvement in leisure activity apart from the perceived constraints, further investigation on the linkage between these two concepts is needed for different types of activities.[4]

A nationwide study was conducted to assess the motivations and constraints of outdoor recreation participants across the United States. The nation's top motivations included: getting exercise, being with friends and family, keeping physically fit, observing scenic beauty, and being close to nature, whereas gaining a sense of accomplishment, gaining a sense of self-confidence, and talking to new people were among the least common motivations for users. The report also indicated that the top five frequent constraints to participating in outdoor recreation consisted of being too busy with family responsibilities, high equipment costs, lack of people to participate with, lack of skills or abilities, and physical disability. Less common constraints included having household members with a disability and fear of being hurt by other people.[5]

Although the national study is useful in understanding the overall commonalities in the United States, lack of local and regional studies might overlook the uniqueness and characteristics of a specific location. Motivation and perceived constraints for participating in outdoor recreation differ based on socio-demographic differences (such as in age, gender, or geographic location) that shape perceptions and opportunities in choice of leisure behavior.[5] Other factors that affect motivation or provide constraints may include weather, economics, and information. As outdoor recreation has become symbolic of the American lifestyle, the state park division in South Dakota has recognized the need of further understanding the needs and barriers of state residents in 2013 and decided to take a proactive approach to conduct statewide studies in assisting to provide high quality outdoor recreation resources and opportunities for the public.[6] Therefore, the purpose of this study is to use residents of the state of South Dakota as the target population to understand local residents' motivations and constraints in outdoor recreation and investigate the relationship between motivations and constraints in outdoor recreation.

Recreation Motivations

Recreation motivations have been of interest to academics and practitioners in explaining and determining why people participate in outdoor recreation and how to fulfill their desired needs. Motivations are factors that direct a person's actions and are generally categorized in two types: intrinsic and extrinsic motivation.[7] Individuals who are intrinsically motivated take part in an activity for the internal fulfillment that accompanies the activity. Alternatively, individuals who are extrinsically motivated participate in an activity due to some type of reward or punishment at the end of the activity. Intrinsic motivation has been defined in four approaches: free-choice, interest and enjoyment, optimal challenges, and innate psychological needs such as autonomy, competence, and relatedness.[8] Researchers also applied self-determination theory to explain extrinsic motivation with four approaches to characterize regulations. Integrated regulation refers to actions that are highly aligned with a person's goals and values, identified regulation refers to the acceptance of a behavior because it aligns to a person's goals and values, introjected regulation references behaviors that occur due to external values or attitudes, often associated with avoiding negative opinions from other people, and external regulation refers to behaviors people take part in for the sole purpose of earning a reward or avoiding punishment at the end of a behavior.[9]

Outdoor recreation or leisure participation usually fosters a freedom of choice and intrinsic motivation, while self-determination in leisure time engagement is fostered by providing opportunities

for personal choice and control, using rewards to reinforce the experience, and encouraging the internalization and integration of extrinsic regulation.[10] Internal motivators have been commonly emphasized in studying outdoor recreation. Outdoor recreation motivation has been evaluated through assessing the importance of desired experiences, such as achievement or sense of accomplishment, enjoyment of nature, escape from daily life, and socialization in the outdoors with family and friends.[11] One study applied motivation theory to investigate usage of Georgia State Parks.[12] The results of the study identified four factors that influence common motivations for outdoor recreation, including social interaction, physical health and fitness, relaxation and restoration, and nature interaction.

Leisure Constraints in Outdoor Recreation

Leisure constraints are defined factors that individuals experience that may inhibit or stop participation in an activity.[13] In the past three decades, leisure constraints theory has evolved and applied to various leisure activities including sport, travel, and outdoor recreation. There are three types of leisure constraints commonly discussed in literature. Intrapersonal constraints refer to internal constraints regarding an individual's internal attitudes and feelings towards an activity, such as the fear of nature, while interpersonal constraints concern an individual's personal relationships and ability to find companions to participate in activities with, such as having no friends or family to go hiking with. Finally, structural constraints refer to external constraints related to the availability of resources necessary to participate in leisure activities, including the lack of time or money to participate in outdoor recreation.[14]

More recently, a hierarchical model and approach emphasizing the "negotiation" process has been proposed.[15] This model explains how individuals overcome and negotiate constraints against participation. For example, individuals must first overcome intrapersonal constraints, followed by interpersonal constraints, and lastly structural constraints.[11,13] Negotiation strategies include time management, financial decisions and adjustments, and skill and technique acquisition.[15] The negotiation model suggests that constraints are not permanent barriers that inhibit leisure participation. Rather, people have the ability to overcome constraints.[11]

Various other researchers have proposed alternative theories to the hierarchical model of constraints. Leisure constraints have also been categorized into two groups: static and dynamic. Static characteristics do not change much over time while dynamic constraints are variable.[8] Other theorists proposed four categories of structural constraints: natural environment structural constraints, social environment structural constraints, territorial structural constraints, and institutional structural constraints.[16]

Methods

The data for this manuscript was derived from larger outdoor recreation research in South Dakota that included both residents and visitors. For the purpose of the study, we only included the cases self-identified as South Dakota residents for further analysis. We collected data through convenience sampling, reaching out to as many potential participants as possible. The Division of Parks and Recreation of South Dakota Department of Game, Fish, and Parks (GFP) shared the survey information via email invitation and social media to the general public. The online survey was available for two months in the fall of 2017. Prior to data collection, the South Dakota State University (SDSU) Institutional Review Board (IRB) approved the study (IRB-1707001-EXM). There were 1,888 research participants self-identified as South Dakota residents, but only 1,212 completed the survey. Incomplete surveys included missed responses and skipped questions and were excluded from further analysis. The completion rate of the public survey was approximately 58%.

The survey questionnaire was developed by adapting several instruments to fit the research purpose: 18 items from Outdoor Recreation Motivations, and 20 items from Constraints to Outdoor Recreation.[2,8,11,12] The researchers integrated these instruments' items to avoid duplications and modify a few items, including weather condition and aging, based on the feedback from GFP's staff in order to fit the needs of the target populations. Research participants rated each item of motivation and constraints using a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree), where a higher score indicated a higher level of motives and barriers involved in participating in outdoor recreation. The Cronbach's alphas of the outdoor recreation motivation and constraints to outdoor recreation were .88 and .89 respectively.

General demographic information was collected including age, gender, race, household income, employment status, and education for an understanding of the research participants. A behavioral component was included to determine the outdoor recreation participation frequency of research participants in the past year. Descriptive analysis was employed to explain South Dakota residents' outdoor recreation motivations and constraints. Finally, the research participants' total scores of outdoor recreation motivations and leisure constraints were computed. Pearson r correlation was used to investigate the relationship between outdoor recreation motivations and leisure constraints. A two-tailed test at a level of 0.05 significance was used to evaluate the correlation between factors.

Results

A majority of research participants were male (73.3%) and between the age of 35 to 64 (62.7%). Slightly above 60 percent of participants had a Bachelor's degree or higher. More than 80% of research participants reported their household income during the past year was $50,000 or more. A majority of research participants were employed in a full-time position, while 23.6% identified themselves as retired. Ninety-five percent of research participants were Caucasian/White, while other ethnic groups were relatively small. As for frequency of outdoor recreation participation, approximately 60% participated in some form of outdoor activities at least once a month in the last year.

The results indicate that the highest motives for participating in outdoor recreation are to *enjoy favorite activity* (M = 4.55, SD = .68) and *beautiful scenery* (M = 4.42, SD = .68) (Table 2). These dominant motives are followed by other motives of participating in outdoor recreation, such as for *relaxation* (M = 4.37, SD = .72), *experience peace/tranquility* (M = 4.26, SD = .80), and *to be with family and friends* (M = 4.26, SD = .79). Other mean scores of outdoor recreation motivations were above three out of five, except for *to meet new people* (M = 2.77, SD = 1.00).

The result of Person r correlation showed that a significant but negative correlation between participants' outdoor recreation motivation and constraints ($r = -.16$, $p < .001$).

Discussion

Understanding the local residents' motivations and constraints in outdoor recreation in South Dakota is essential for promoting outdoor recreation opportunities and providing quality and accessible outdoor areas and facilities for the state. Outdoor recreation provides potential environmental, social, and personal benefits to the community. With a proactive approach to foresee future needs and potential challenges, the study was able to identify the common motivations and perceived

Table 1: Demographics of Research Participants

Demographics & Frequency	Frequency	Percentage
Gender		
Male	914	73.3%
Female	333	26.7%
Age		
18-24	35	3.0%
25-24	145	12.5%
35-44	216	18.5%
45-54	227	19.5%
55-64	287	24.7%
65-74	203	17.5%
75+	50	4.3%
Education level		
Less than high school	8	0.6%
High school graduates	157	12.6%
Some college or associate's degree	324	26.1%
Bachelor's degree	450	36.2%
Graduate or professional degree	304	24.5%
Household income		
Less than $15,000	18	1.5%
$15,000 to $24,999	41	3.4%
$25,000 to $34,999	58	4.9%
$35,000 to $49,999	141	11.8%
$50,000 to $74,999	275	23.1%
$75,000 to $ 99,999	222	18.6%
$100,000 to $ 149,999	218	18.3%
$150,000 and more	157	10.1%
Refused/I don't know	99	8.3%
Employment status		
Full-time employed	814	66.9%
Part-time employed	64	5.3%
Unemployed	10	0.8%
Retired	287	23.6%
Other	42	3.5%
Race		
White	1175	95.8%
Black	3	0.2%
American Indian	6	0.5%
Asian	4	0.3%
Pacific islander	1	0.1%
Two or more races	9	0.7%
Other	28	2.3%
Outdoor Recreation Frequency Last Year		
Two or more time per week	*428*	*35.3%*
About once per week	*300*	*24.7%*
About once or twice per month	*239*	*19.8%*
Several time during the year	*185*	*15.3%*
Once or twice during the year	*32*	*2.6%*
None last year	*24*	*2.0%*
Never	*4*	*0.3%*

Table 2: Summary of Descriptive Analysis of Outdoor Recreation Motivation

Motivations	Mean	SD
To enjoy my favorite activity	*4.55*	*0.68*
To enjoy beautiful scenery	*4.22*	*0.68*
For relaxation	*4.37*	*0.72*
To experience peace/tranquility	*4.26*	*0.80*
To be with family and friends	*4.26*	*0.79*
To observe wildlife	*4.22*	*0.82*
To escape daily routine	*4.11*	*0.89*
For stimulation and excitement	*4.07*	*0.87*
To keep physically fit	*3.84*	*0.94*
To feel at one with nature	*3.82*	*0.97*
To experience new things	*3.78*	*0.90*
To develop skill and knowledge	*3.74*	*0.88*
To use my outdoor gear/equipment	*3.72*	*1.00*
To challenge myself	*3.71*	*0.98*
To gain sense of accomplishment	*3.59*	*0.95*
To learn about the environment	*3.49*	*0.96*
To develop confidence in myself	*3.10*	*1.03*
To meet new people	*2.77*	*1.00*
Total Motivation*	*69.71*	*9.39*

**Cronbach's alpha of motivation instrument = .88*

Table 3: Summary of Descriptive Analysis of Outdoor Recreation Contstraints

Constraints	Mean	SD
Don't have enough time	*3.09*	*1.22*
Parks and recreation areas are too crowded	*2.86*	*1.11*
Equipment costs are too high	*2.74*	*1.07*
Admission fees are too high	*2.51*	*1.10*
Activity fees are too high	*2.48*	*1.13*
Weather (i.e., extreme cold or hot temperatures)	*2.39*	*1.08*
Age (i.e. busy with kids activities now, unable to physically participate in the same activities, etc.)	*2.34*	*1.13*
Companions prefer other things	*2.29*	*1.02*
Don't have people to go with	*2.30*	*1.13*
The facility I want doesn't exist in parks	*2.29*	*1.02*
Lack of information	*2.13*	*1.01*
Don't have the skills or physical ability	*2.07*	*1.00*
Don't have necessary equipment	*1.94*	*0.90*
Nearby parks are dirty or poorly maintained	*1.90*	*0.85*
Concern about safety / crime	*1.89*	*0.86*
Don't feel welcome	*1.88*	*0.86*
Lack of interest	*1.76*	*0.87*
Lack of confidence	*1.76*	*0.83*
Afraid of getting hurt by animals /insects	*1.66*	*0.86*

**Cronbach's alpha of constraints instrument = .89*

constraints among resident participants in outdoor recreation in South Dakota. Three major contributions in this study were:

1. The residents in South Dakota who participate in outdoor recreation were highly driven by internal motivations: enjoying the activity of choice, appreciating the beauty of nature, relaxing, and experiencing tranquility. They also participated in some form of outdoor recreation at least once per week.
2. The leisure constraints of South Dakota's residents were consistent with those found in other existing studies on similar topics. For example, the stronger perceived constraints were structural, such as time and cost.[5,17,18] Although overall interpersonal constraints and intrapersonal constraints were relatively less obvious than structural constraints, crowding issues at parks and recreation areas, unexpected weather conditions, and concern about aging were common barriers in the study.[7]
3. Although the correlation between research participants' recreation motivations and leisure constraints was statistically significant, the relationship might be identified as a small or weak relationship between the two variables.[19] It is possible that the majority of research participants were "regulars" in outdoor recreation with high inner motivations and dedication to their favorite outdoor activities and being through "negotiation" process to overcome the various constraints.

Although these findings make a unique contribution to understanding outdoor recreation motivations and leisure constraints, focused on South Dakota residents, there are several limitations in the study. These limitations may provide opportunities for further inquiry. Convenience sampling and a single email invitation were the only approaches used to recruit potential research participants. Future studies might target specific segments or activity participants (hunters, anglers, and campers, for example) or compare motivations and constraints between outdoor recreation enthusiasts and non-outdoor recreation participants to further the understanding of the similarities and differences among groups. By doing so, outdoor recreation providers would be able to provide programs for South Dakota residents with different levels of experience, skills, and commitment in outdoor recreation to assist in overcoming constraints. Moreover, the study primarily applied descriptive analysis with correlation testing for a comprehensive understanding of South Dakota residents' motivations and constraints in their outdoor recreation pursuit. A more advanced analysis might reveal further in-depth information from the study.

Conclusion

The study of South Dakotans' perceptions of outdoor recreation revealed trends in both participants' motivations and constraints. Based on the findings, people in South Dakota are primarily intrinsically motivated to take part in outdoor recreation. The most common motivations among respondents included: to enjoy my favorite activity, to enjoy beautiful scenery, for relaxation, to experience peace/tranquility, and to be with family and friends. A majority of survey participants have a genuine, internal desire to participate in various outdoor recreation activities. Recreation providers can use this information to improve their parks in facilities in a manner that will increase users' intrinsic motivations.

South Dakota's population primarily reported structural constraints that inhibit their participation in outdoor recreation. Participants listed lack of time, overcrowding, high equipment costs, and high admission fees as top constraints to their involvement in recreation. Based on the hierarchical model of constraints, structural constraints are the last barrier people must overcome in order to participate in an activity. Therefore, South Dakotans are willing to overcome both intrapersonal and interpersonal constraints but struggle to overcome structural constraints. Outdoor recreation providers can utilize this information to make parks and facilities more accessible to a more diverse population.

Acknowledgements

This research is funded by the Division of Parks and Recreation of South Dakota Department of Game, Fish, and Parks (GFP). The authors acknowledge the support from GFP staff and park managers for their input and contribution to the project. We also thank the South Dakota Parks and Recreation Association (SDPRA) members for their help in distributing the survey.

References

[1] Driver, B. (2008) *Managing to Optimize the Beneficial Outcomes of Recreation*. Venture Publishing. Pg 19-34.

[2] Kil, N., Holland, S., and Stein, T. (2014) "Structural Relationships between Environmental Attitudes, Recreation Motivations, and Environmentally Responsible Behaviors." *Journal of Outdoor Recreation and Tourism.* 7. Pg 16-25.

[3] Moghimefer, F. and Halpenny, E. (2016) "How do people negotiate through their constraints to engage in pro-environmental behavior? A study of front-country campers in Alberta, Canada." *Tourism Management.* 57. Pg 362-372.

[4] Alexandris, K., Tsorbatzoudis C., and Grouios, G. (2002) "Perceived Constraints on Recreational Sport Participation: Investigating their Relationship with Intrinsic Motivation, Extrinsic Motivation and Amotivation." *Journal of Leisure Research.* 34.3. Pg 233-252.

[5] Outdoor Foundation. (2017) "Outdoor Participation Report 2017." Outdoor Industry Association.

[6] South Dakota Department of Game, Fish, and Parks. (2013) "2013 Statewide Comprehensive Outdoor Recreation Plan". Division of State Park of South Dakota Department of Game, Fish, and Parks.

[7] Shores, K., Floyd, M., and Scott, D. (2007) "Constraints to Outdoor Recreation: A Multiple Hierarchy Stratification Perspective." *Leisure Sciences.* 29. Pg 227-246.

[8] Vallerand, R. and Losier, G. (1999) "An Integrative Analysis of Intrinsic and Extrinsic Motivation in Sport." *Journal of Applied Sport Psychology.* 11.1. Pg 142-169.

[9] Deci, E. and Ryan, R. (2000) "The 'What' and 'Why' of Goal Pursuits: Human Needs and the Self-Determination of Behavior." *Psychological Inquiry.* 11.4. Pg 227-268.

[10] Mannell, R. and Kleiber, D. (2011) *A Social Psychology of Leisure*. Venture Publishing Inc. Pg 158-160.

[11] White, D. (2008) "A Structural Model of Leisure Constraints Negotiation in Outdoor Recreation." *Leisure Sciences.* 30. Pg 342-359.

[12] Whiting, J., Larson, L., Green, G., and Kralowee, C. (2017) "Outdoor recreation Motivation and Site Preferences Across Diverse Racial/ethnic Groups: A Case Study of Georgia state parks." *Journal of Outdoor Recreation and Tourism.* 18. Pg 10-21.

[13] Schneider, I. and Wynveen, C. (2015) "Exploring outdoor recreation conflict's role in evolving constraints models." *Journal of Outdoor Recreation and Tourism.* 9. Pg 37-43.

[14] Jackson, E., Crawford, D., and Godbey, G. (1993) "Negotiation of Leisure Constraints." *Leisure sciences.* 15.1. Pg 1-11.

[15] Hubbard, J., and Mannell, R. (2001) "Testing competing models of the leisure constraint negotiation process in a corporate employee recreation setting." *Leisure Sciences.* 23.3. Pg 145-163.

[16] Walker, G. and Virden, R. (2005) *Constraints to Leisure*. Venture Publishing. Pg 201–219.

[17] Berns, G. and Simpson, S. (2009) "Outdoor Recreation Participation and Environmental Concern: A Research Summary." *Journal of Experiential Education.* 32.1. Pg 79-91.

[18] Nyaupane, G. and Andereck, K. (2008) "Understanding Travel Constraints: Application and Extension of a Leisure Constraints Model." *Journal of Travel Research.* 46.4. Pg. 433-439.

[19] Vaske, J. (2008) *Survey Research and Analysis: Applications in Parks, Recreation and Human Dimensions*. Venture Publishing. Pg 415-420.

Germany's Children: Marriage and Reproductive Policies under National Socialism during World War II

By Samantha Sullivan
University of Vermont

Introduction

The Second World War and its effects on the German population were significantly affected by the policies concerning reproduction and marriage created by the Nazis. While Hitler planned from the beginning to recreate Germany in the image of the perfect Aryan race, World War II exacerbated the burden on women to have children. Essentially, this burden was two pronged: On the one hand, the high death toll on the battlefront required a near-constant stream of new soldiers to fight on behalf of Germany. For Hitler, this meant that women needed to have more children so that they could replace those lost in battle.[i] In a speech given at the National Socialist Party of Germany's (NSDAP) Congress, Hitler proclaimed, "the goal of female education must invariably be the mother."[1] The Nazis believed that a formal education for the sake of education, or with the hopes of one day having a career, was unnecessary. The only purpose women served was as mothers, and education was only necessary to the extent that women used it to raise a better generation of Germans.

At the heart of many Nazi social policies, including those focused on regulating reproduction and sex, was a desire to incorporate traditional Christian values. Generally, these tenants of Christianity included female subordination, evasion of premarital sex, and out-of-wedlock births, which Christians and Nazis alike saw as symptoms of an immoral society. Especially coming out of the progressive and liberal Weimar Period, Hitler and the NSDAP saw an absence of moral values in German society. However, the Nazis' relationship with those Christian ideas was complicated, and as a result, they often cherry picked which aspects of Christianity to adopt in their own platform, while criticizing the Church for others.[ii,2] In general, the Church and the Nazi party were engaged in a power struggle over creating a properly moral society according to their own platforms (which was certainly one root of the tension between them) but ultimately had similar visions for German society.

To encourage motherhood as an ideal for women and to bring traditional Christian values back into daily life, the National Socialist government of Germany redefined marriage in a way that forbid so-called deviants from participating in the institution. Legitimate marriage in Nazi Germany was defined as:

A long-term relationship based on the mutual trust, love, and respect between two genetically healthy and racially identical people, of opposite gender with the aim of conceiving genetically healthy Aryan children and raising them to be able-bodied national comrades.[3]

All of these elements – marriage, nationalism, and child bearing – are important in understanding the politics of gender under Nazism. Ultimately the Nazis based their gender policies on the idea that motherhood was the only proper role for women in Germany. Their legislation regarding sex and sexuality, education, and the workforce was intended to encourage reproduction and motherhood and acted as a disincentive for women to seek out alternative lifestyles.

Gender as an analytical category helps explain the life and culture of the average German person during the war. This paper will explore Nazi gender policies and their attitudes towards sex, reproduction, and marriage as they existed between 1939 and 1945. Specifically, it will discuss the positive eugenics project instated by the Nazis that encouraged reproduction. This will shed light on constructions of femininity in Nazi Germany, after which it will attempt to show how these policies defined the roles women played in society at large and how they translated to their participation in the war effort. In order to understand these impacts, however, the paper will begin by briefly reviewing gender policies under previous German governments and then contrast those with the changes made under National Socialism.

Most of the evidence used in this paper to support the thesis comes from secondary analyses of Nazi reproductive policies and of German culture and society under the Third Reich. They proved to be the most efficient sources for conveying the effects of those policies and, as such, serve as a critical underpinning to the analysis. However, this paper relies heavily on primary sources as well, including speeches presented at Nazi rallies that touched on these reproductive policies and firsthand accounts of the conditions of life for German women. Specifically, Alison Owings' book *Frauen* collects and documents the stories of women who lived through the Third Reich and illustrated the emotions women felt and the incentives women had to reproduce. Ultimately these primary sources showed women's reactions to Nazi reproductive policies and conveys how the women perceived the impacts of those policies in their own lives.

Weimar Era

The Weimar Era identifies the German state between the end of World War I in 1918 and Adolf Hitler's appointment to Chancellor in 1933. This period is defined by a progressive German republic, replacing its previously imperialist monarchy. More specifically, the tension between the Social Democrats and the Communists, the two dominant parties in Weimar Germany, centered around how to best carry out these progressive changes. The Communists, in true Marxist fashion, looked to Russia and believed that violent revolution and combat were necessary and the only ways to truly eliminate the monarchy.[iii]

The Social Democrats, a more moderate party, believed political reform, would be a more effective method. Despite their different approaches to enacting social change, both of these groups, as well as the Nazi Party that emerged towards the end of the Weimar Era, dealt with gender ideals.

The Communist Party of Germany (KPD) – a large minority in the political sphere – made the physically powerful, militaristic male proletarian the center of its politics, while women were rendered the passive objects of capitalist exploitation and proletarian sympathy.[4] The KPD is important because, despite their minority status, they still exerted quite a bit of influence in terms of enacting progressive

legislation; more importantly, they challenged the conceptions of gender later presented by the National Socialists. Among many social reforms carried out during Weimar, several important policies specifically affected gender and sexuality, namely an increased access to birth control and legal abortions, which emphasized women's sexual freedom.[5] Despite the significant taboos that still existed regarding sex for pleasure at the time, 72 million condoms were sold in Germany in 1938.[5] Furthermore, the KPD equated marriage with prostitution and defended single women's rights to a sexual life.[4] They emphasized the importance of the full and active participation of women in all realms of life and worked to integrate them into the proletarian class struggle.[4] This emancipatory message, however, would not last long.

While the Communists "asserted the full equality of men and women," which appeared in many of the policies passed during the Weimar Era, the Nazis would come to reverse these changes. The Nazi Party saw this as a problem leading to the corruption of German society They argued that this corruption was a continuation of that perpetuated by the Jews.[6] In order to undo the changes made during the Weimar Era, the Nazis believed they must return to or reinvent the societal values that existed under Germany's monarchy. Part of this revolved around the roles men and women were expected to occupy, which were based in Christian values and morality. Thus, they asserted that the unequivocal role of women was procreation.

Reproduction under the National Socialist Party

Once the National Socialist Party of Germany came to power in 1933, public attitudes towards reproduction began to change. From his first day in office, Hitler claimed that the country's survival depended – among many things – on the reversal of the devastating demographic decline. He attributed this to the lenient views held during the Weimar era that birth control and abortions were acceptable, both of which worked to bring down the birth rate in Germany. Thus, Hitler and his party crafted a plan for the restoration of German society; at the center of this plan was the creation of an indivisible and racially pure community. Hitler saw this idealized population as a solution to the social ills resulting from the Weimar era, a period that the Nazis attempted to erase from German history altogether, denouncing it as "a historical aberration."[3] Hitler and the Nazis encouraged members of the supposedly superior Aryan race to create this new population by cultivating a "cult of motherhood" that emphasized that the most important role for women was reproductive.

One major way by which the Nazi Party took steps to create a racially homogenous state was through its views and policies on sex and reproduction. The Nazis took a hostile approach to sex, denouncing it as a pleasureless act.[5] By taking away the idea that sex could be enjoyable at all, the Nazis hoped that men and women would only engage in sex with the end goal of pregnancy so that promiscuity would disappear and the need for birth control would be eliminated. Through propaganda campaigns, the Nazis were sure to emphasize sex's utilitarianism; it had a specific purpose – reproduction – and engaging in sex for any other reason would be shameful. Moreover, they greatly restricted access to birth control and completely forbade abortions, which removed the so-called safety net for individuals practicing unsafe sex.[in, 1] As a result, Hitler hoped to eliminate non-reproductive sex. While that is a difficult metric to gauge, the propaganda campaigns were at least highly successful in pushing this type of behavior underground so that it was no longer a cultural marker, the way it was during the Weimar Era. This would eventually reinstate traditional Christian values of modesty while simultaneously increasing the population. Furthermore, it was the belief of several important Nazis that the Jewish community had led Germany astray in this regard. More specifically, a Nazi-identified doctor named Ferdinand Hoffman believed that Jewish doctors during the Weimar era promoted birth control and contributed to its popularity and widespread use.[1] He thought that sex for pleasure was an "attack on Christian values".[1] Hitler also repudiated the idea of women's emancipation, again blaming the Jewish community.[6] As a result, the Nazis developed a eugenics project to try to repair traditional morals and erase the groups the Nazis deemed inferior. Here we see evidence of how Nazi anti-Semitism came to affect its reproductive politics during World War II.

While the eugenics project in Germany started before the breakout of the war in 1939, the conditions brought about by World War II drastically changed the program and made it more important. Hitler pledged to rejuvenate German families by eliminating immorality and restoring the traditional patriarchal family and moral order. He insisted that new family policies echoing traditional German values would create jobs for men, restore the patriarchal family, and strengthen the Aryan race. Hitler promised that in the Third Reich, every woman would be able to marry and answer her natural calling to bear children.[3] The Nazi eugenics movement was twofold: it had both a so-called negative and positive track. The negative track, simply, is the one we would most associate with the Holocaust and eugenics in general. It was the forced sterilization and murder of people perceived to be inferior. Essentially anyone who was gay, black, Jewish, mentally ill, a criminal, or did not support the Nazi regime was to be forcibly sterilized or sent to their deaths in concentration camps. The purpose was to end the continuation of these "degenerate" races, prevent people with contagious diseases and inherited disabilities from passing those problems onto a future generation, and, in the case of gays and lesbians, who could not have children, to punish them for not breeding.[6] Between 1934 and 1939, approximately 320,000 people were forcibly sterilized, a figure which includes 5,000 "eugenic" abortions.[1] Furthermore, from 1939 to 1941 over 70,000 mentally and physically handicapped adults were murdered as so-called "useless eaters" and "lives unworthy of life".[1]

Positive Eugenics

The second track is what is often referred to as positive eugenics, which means that certain people were encouraged to reproduce. Through increased propaganda campaigns, the Nazis promoted the continuation of the Aryan race by painting their version of sexuality as natural, as the beauty of the race itself. Within the positive eugenics project, the Nazis created laws and campaigns that served either as incentives to have children or as challenging hurdles to pass if one did not. During the war, almost half of the 20 million men who served in Germany's military had left civilian life, which made marriage and having children more difficult for women on the home front.[3] Since marriage and childbearing were the pinnacle of success, as the Nazi definition of marriage implied, this shortage of men became a serious problem for ordinary German women. Not only had they found an immediate need for more soldiers, but, more importantly, they saw a long term need to have people to whom they could teach their ideas and doctrines once the war was over. Thus they

took desperate steps to ensure that babies were being born.

Most of their steps towards punishing women who did not have children were well-enforced laws.[v, 3] They also criminalized birth control and abortions for genetically healthy Aryans; in fact, a common saying about abortion during the war was "better ten on the pillow than one on your conscience," which reinforced the importance of reproducing.[7] From 1943 onwards, women who sought an illegal abortion, as well as those who helped them, could face the death penalty.[1,6] The Nazis went to extreme lengths to ensure that women carried their healthy children to term, but there were nevertheless contradictions and problems inherent in their abortion policies.

The Nazis' view of abortion was a double-edged sword: On one hand, healthy births were never to be interfered with, but, on the other hand, the modified Law for the Prevention of Inherited Diseases of 1935 legalized abortion under certain circumstances.[6] This law essentially gave the Nazis the right to forcibly abort the fetuses of "genetically inferior" parents under the guise of preventing the spread of certain illnesses and conditions, which often included race. Beyond this, the NSDAP also created an experimental breeding project in 1940, led by Heinrich Himmler, known as the *Lebensborn Program*. This program involved the establishment of special maternity homes for the "racially valuable" wives of young SS men, but also for unmarried mothers of "good blood" who had fallen pregnant by soldiers serving at the front.[1] This project essentially served two functions. First, it provided government-funded housing for women who already had "racially valuable" children and needed financial assistance raising them. These houses also served as a brothel of sorts, where soldiers on leave could serve as "conception assistants" to women hoping to get pregnant.[1] Once impregnated, these women would remain in the houses to give birth. Additionally, since the homes were owned and operated by the Nazis, children grew up in an environment which exposed them to National Socialist rhetoric from day one. The *Lebensborn* homes also served as an illustration of the Nazi anxiety about producing healthy children because of how visibly deformed children were handled.[6] If a woman gave birth to a child with genetic imperfections, the Nazis took that child away. [vi, 8]

Another way in which Hitler encouraged procreation was by closing off professional opportunities to women. The purpose was to ensure that women had no other option than to bear children. In other words, Nazi policy was meant to control women's careers and lives.[9] It was said that the German mother had the most important job for "the future of [the] *Volk*" and many Nazis believed that the mother of multiple children was worth more than one educated woman.[10] Furthermore, women's employment, especially for married women, "was generally full of disadvantages," which could only be escaped by fulfilling her role in the family.[10] Joseph Goebbels, the Nazi Minister of Propaganda and Hitler's right-hand man, once said that "the most glorious task [a woman] can perform is to give the gift of children to her people and the nation".[16] In order to promote this motherly ideal, Hitler began to close off opportunities for women to pursue degrees in universities and jobs in professional settings, outside of social work, which was deemed "properly suited" for women.[vii,9] For example he announced in 1936 that women could no longer be hired as judges or lawyers.[9] For the next several years all legal careers, such as medicine and teaching, were closed to women. As a result, they had to resign themselves to their motherly duties because it was the only thing they could do.[9]

In 1943, however, there was a massive shift in employment policy. The Germans were losing the war on the Eastern front and needed bodies to replace the men who had been drafted and became war casualties. Hitler had always worried that conscripting women would contradict their biological role, but in January 1943, the pressures from the war were too great, so the state began drafting women between the ages of seventeen and forty-five into war-related work. However, this still consisted mostly of "racially unworthy" women and young, unmarried Aryan women.[9] The Nazis subsequently reopened the fields of medicine and teaching to women as well, but not because of a shift in ideology; instead, it was because the German Army had drafted and lost so many doctors and teachers that women needed to adjust to real world demands and fill those important professional vacancies.[9] Regardless, because they lacked the necessary formal education due to restricted educational opportunities, only forty-five percent of women over fourteen were qualified to be employed by spring of 1944.[9] It is important to note that the integration of women into the wartime workforce was not intended to challenge the fundamental belief that after the war, women's primary focus would return to family and household.

The NSDAP created many more incentives for men and women to have children. Economically, there were tax breaks for large families and state sponsored marriage loans contingent upon women leaving the workforce.[3] There was also an increase in the number of health clinics to advise and support mothers. In 1941, a Führer's decree also made "postmortem marriages" possible. During the war, around 18,000 pregnant women married the corpses of their child's father, who was killed in battle, in order to become eligible for widows' benefits and to legitimize their children.[3] The Nazis also worked to revamp Mother's Day, which would hopefully inspire young women to want to bear children, and created the Mother's Cross to publicly honor worthy German mothers. One woman recounted that women were entitled to be "bursting with pride" when they had given birth to as many children as possible. In fact, it was only then that women had fulfilled their "greatest purpose in life".[viii,11] According to one German newspaper from the time, *Das Schwarze Korps*, these efforts worked to bring back "the beauty of the German mother" and such prolific childbearing reflected the "immortality of the German *Volk*".[ix,12]

Another policy the Nazis created to further incentivize childbirth among young women was the Mother's Cross. As the name implies, the Nazis honored women who gave birth to many children and was popular even before the war; by 1939, over three million mothers had already been honored with the cross.[6,10,12] One woman featured in Alison Owning's book *Frauen*, named Wilhelmine Haferkamp, spoke in depth about her Mother's Cross. At first, she got the bronze Cross after having four children. She gave birth to two more children and was awarded the silver Cross. After having a total of nine babies, Haferkamp was awarded the longed-for gold Cross. She recalls being "really proud of it".[7] She even describes a celebration party for her thrown by other mothers at a local school and how she was unable to go because she had nine young children to care for. Clearly this cross was not only a sign of personal achievement but also of a strong standing in one's community. It was, essentially, a way for women to become war heroes.

Women who earned the Cross later received additional benefits as well, some as trivial as priority seating on the trams. Haferkamp also remembers how the NSDAP rewarded Cross recipients. When parents with lots of children were members of the Nazi party, their children had a greater chance to advance because they were exposed to special opportunities. Haferkamp said she got fifty marks per child per month. When she multiplied that

by nine children, she ended up making a lot of money. In fact, she sometimes got more "child money" than her husband earned at his job. What's more, because Wilhelmine's husband was a Party member, his children also got more schooling than they would have otherwise because the Party paid for their education.[7] The Nazis paid careful attention to rewarding the women who were compliant with their policies and ensured the success of their children. After all, they were Germany's children, too.

Conclusions

Ultimately, while Nazi reproductive policies during World War II did not have a significant effect on the battlefield, they absolutely changed – and even destroyed – the worlds of German citizens on the home front. These policies put women in a sociopolitical straightjacket, where their mobility in society was defined by the number of children they bore. Only the "best" Aryans could continue the German population and reinstate traditional family and religious values. For both men and women, raising the future of Germany and the Aryan race was the most patriotic and important job a person could have, even though the actual child-rearing often fell on the shoulders of the mother. Unfortunately, the legacy of Nazism in West Germany after the war was manifested in the documentation of widespread child abuse. This behavior was so harsh it is sometimes described as being similar to private concentration camps; one interpretation of this is that aggression can be a result of sexual repression.[13] As one author put it, "It would be wrong to hold the view that all of what happened in Auschwitz was typically German. It was typical for a society that suppresses sexuality".[14] Additionally, women in Germany in the postwar period continued to face hardship because all of the Nazi policies rewarding motherhood were overturned. Savings accounts filled with "child money" were dissolved and government-owned homes were shut down.[7] From 1945 onward, German women were forced to care for many children without a husband or financial support from the government.

The irony in all of this is that in the 1960s, West Germany became a hotbed for the transatlantic sexual revolution, the complete opposite of what the Nazis wanted. Children born during the war as results of these reproductive policies were maturing and rebelling against their conservative, former-Nazi parents. In conjunction with second-wave feminism, men and women in Germany sought to create a sex-positive environment which would liberate themselves from their nation's horrific past. This youth rebellion was fueled by the hypocrisy of parents, teachers, and public officials who had helped carry out the discriminatory policies of the Nazi regime, yet hid "behind properness" in the post-war period.[13]

The significance of understanding the roles sexuality and gender played during the war in German society is that we are able to comprehend the vast appeal of Nazism to people who, like Hitler, sought a resurgence in traditional family values. After all, bringing back the patriarchal system destroyed during Weimar was one of the Nazi party's goals. Conservatives who wished to restore Germany latched onto Hitler's ideology without understanding the consequences of a state-sponsored eugenics projects. Thus, we also see the impacts of nationwide sexual repression, in terms of both aggressive behavior towards children and those in concentration camps, as well as the creation of new sexual scripts that people, especially women, were required to follow. These scripts were carried into postwar period until the sexual revolution of the 1960s, by which point the German people worked to completely reverse them. Women were tired of assuming a maternal role, so they worked to create a nation in which they could be sexual beings and participate in the professional sphere. The new gender policies that emerged from these social movements worked to give back to women what they had lost just 20 years earlier. Gender will always be political, even today, but this was especially true during World War II in Germany.

Footnotes

i. In part, this mindset was a result of Hitler's ego; he believed not only that Germany would win the war, but that it would be a short fight. Thus, in this sense, his push for women to have children was a short-term solution to a short-term problem.

ii. Some top Nazi officials such as Joseph Goebbels and Heinrich Himmler were outspoken in their anti-Church views. Himmler, for example, claimed that a main goal of the SS was to overcome Christianity and restore a purely Germanic way of life.

iii. The establishment of Weimar Germany came shortly after the Russian Revolution of 1917, so the German Communists recently saw what a successful revolution could look like. The Russians took one of Marx's central tenants, which states that mild political reforms are not enough to enact the communal, property-less society that Communists strive for, to overthrow the Tsar. Therefore, it is important in this context to note the contrast between the violent battle the Communists believed would bring about progressive change in Germany and the political reforms for which the Social Democrats advocated.

iv. Condoms were distributed to soldiers during World War II as a means of protecting them from STDs when engaging in sexual activities with prostitutes. While reversing the changes made during the Weimar Era for gender roles was an important goal for Hitler and the Nazis, winning the war was their highest priority. In order to ensure that the soldiers were able to fight, then, they allowed those men to have sex with prostitutes and distributed condoms to make sure that no diseases were spread. Moreover, abortions were illegal for healthy Aryan couples; often, the Nazis would forcefully abort the fetuses of "deviant" populations, namely, the Jews, criminals, the mentally ill, and gypsies. For more, see: Stibbe, *Women in the Third Reich*, 72.

v. The NSDAP also implemented a bachelor's tax on single men who remained on the home front to incentivize men to have children as well. However, these policies were less likely to affect men or infringe upon their ways of lives. For more, see: Mouton, *From Nurturing the Nation to Purifying the Volk*, 18.

vi. I could not find any sources in English that documented specifically what happened to these children in the *Lebensborn* homes. However, for more information on *Lebensborn*, see: Larry V. Thompson, "Lebensborn and the Eugenics Policy of the Reichsführer-SS," *Central European History* 4 no. 1 (March 1971): 54-77.

vii. Moreover, many Nazi supporters observed that, from the perspective of racial biology, women's employment was "full of disadvantages." To further justify shutting women out of the workplace, they emphasized that a woman's "truest calling" was never in an office, factory, or laboratory, but rather "in the family and in the family alone!" For more, see: Otto Steche, Erich Stengel, and Maxim Wagner, "Womb Wars" (1942), in *The Third Reich Sourcebook,* edited by Anson Rabinbach and Sander L. Gilman (Berkeley: University of California Press. 2013): 334.

viii. Gertrud Altmann-Gädke, "The Maternal Instinct Must Be Reinforced" (1941), in *The Third Reich Sourcebook,* edited by Anson Rabinbach and Sander L. Gilman (Berkeley: University of California Press, 2013): 325.

ix. "Fashion: A Matter for Our Women!" *Das Schwarze Korps* (July 26, 1939), in *The Third Reich Sourcebook,* edited

by Anson Rabinbach and Sander L. Gilman (Berkeley: University of California Press, 2013): 322.

References

[1]Stibbe, M. (2003) *Women in the Third Reich*. Hodder Headline Group.

[2]Longerich, P. (2012) *Heinrich Himmler*. Oxford University Press.

[3]Mouton, M. (2007) *From Nurturing the Nation to Purifying the Volk: Weimar and Nazi Family Policy, 1918-1945*. Cambridge University Press.

[4]Weitz, E. (1996) "The Heroic Man and the Ever-Changing Woman: Gender and Politics in European Communism, 1917-1950." In *Gender and Class in Modern Europe*. Edited by Frader, L. and Rose, S., eds. Cornell University Press. Pg 311-352.

[5]Herzog, D. (2002) "Hubris and Hypocrisy, Incitement and Disavowal: Sexuality and German Fascism." *Journal of the History of Sexuality*.11. Pg 3-21.

[6]Rabinbach, A., and Gilman, S. eds. (2013) *The Third Reich Sourcebook*. University of California Press.

[7]Owings, A. (1993) *Frauen: German Women Recall the Third Reich*. Rutgers University Press.

[8]Thompson, L. (1971) "Lebensborn and the Eugenics Policy of the Reichsführer-SS." *Central European History*.4.1. Pg 54-77.

[9]Mouton, M. (2010) "From Adventure and Advancement to Derailment and Demotion: Effects of Nazi Gender Policy on Women's Careers and Lives." *Journal of Social History*.43.4 Pg 945-971.

[10]Steche, O., Stengel, E., and Wagner, M. (1942) "Womb Wars." In *The Third Reich Sourcebook,* Rabinbach, A. and Gilman, S. eds. University of California Press. Pg 334.

[11]Altmann-Gädke, G. (1941) "The Maternal Instinct Must Be Reinforced." In *The Third Reich Sourcebook,* Rabinbach, A. and Gilman, S. eds. University of California Press. Pg 325.

[12] Das Schwarze Korps. "Fashion: A Matter for Our Women!" (1939). In *The Third Reich Sourcebook,* Rabinbach, A. and Gilman, S. eds. University of California Press. Pg 316-319.

[13]Herzog, Dagmar. (1998) "'Pleasure, Sex, and Politics Belong Together': Post-Holocaust Memory and the Sexual Revolution in West Germany." *Critical Inquiry*.24. Pg 393-444.

[14]Herzog, Dagmar. (2005) *Sex after Fascism: Memory and Morality in Twentieth-Century Germany.* Princeton University Press.

[15]Goebbels, Joseph. (1933) "German Women." In *The Third Reich Sourcebook,* Rabinbach, A. and Gilman, S. eds. University of California Press. Pg 316-319.

Experimental Progress Towards Testing the Behavior of Gravity at the 20-micron Distance Scale

By M.P. Ross[A], J.S. Johnson[A], I.S. Guerrero[A] , H.F. Leopardi[B], and C.D. Hoyle[A]

[A]Department of Physics and Astronomy, Humboldt State University, Arcata, CA;
[B]NIST/University of Colorado, Boulder, CO

Abstract

Due to discrepancies between the Standard Model and General Relativity, questions have arisen about the fundamental behavior of gravity. Many theories have speculated that gravity behaves fundamentally different at short ranges with respect to the predictions of Newtonian theory. These discrepancies have led the Humboldt State Gravitational Research Lab to begin constructing an experiment that will test the behavior of gravity at distances that have yet to be explored. The experiment has been improved upon in many aspects and has entered an initial data acquisition phase.

1. Introduction

1.1 Motivation

The behavior of gravity at short ranges has been called into question by many modern theories. Some speculate that there are extra dimensions with sizes from 100 m to 1 mm which Standard Model particles cannot access, yet gravity can [1]. This would cause gravity to change behavior at distance scales similar to the dimension's size. Also, many variations of string theory call for changes to the behavior of gravity [2, 3]. Short range tests of gravity are one of the few ways in which these predictions can be probed. For a more detailed review, see Reference [4].

1.2 Inverse Square Law Tests

The Inverse-Square Law (ISL) of gravity is a fundamental part of Newtonian gravity and states that the force of gravity is proportional to the inverse-square of distance, $F_g \propto 1/r^2$. Since Newtonian gravity is an approximation for General Relativity in the weak-field limit, tests of the ISL are fundamentally tests of General Relativity. Deviations of the ISL are traditionally parameterized by assuming an additional Yukawa interaction, which gives a potential energy between two point masses as:

$$V(r) = -\frac{Gm_1m_2}{r}(1+\alpha e^{-r/\lambda}), \quad (1)$$

where α is the strength of the deviation and λ is the length scale at which the deviations become relevant. This potential energy can describe many of the possible theoretical situations and simplifies to the Newtonian potential if r >> λ or α = 0. Many ISL test have been conducted which set limits in the α - λ parameter space, as shown in Figure 1. Also shown are two projected sensitivity curves for the Humboldt experiment, described below, which correspond to analyzing only the first or second harmonic of the gravitational signal.

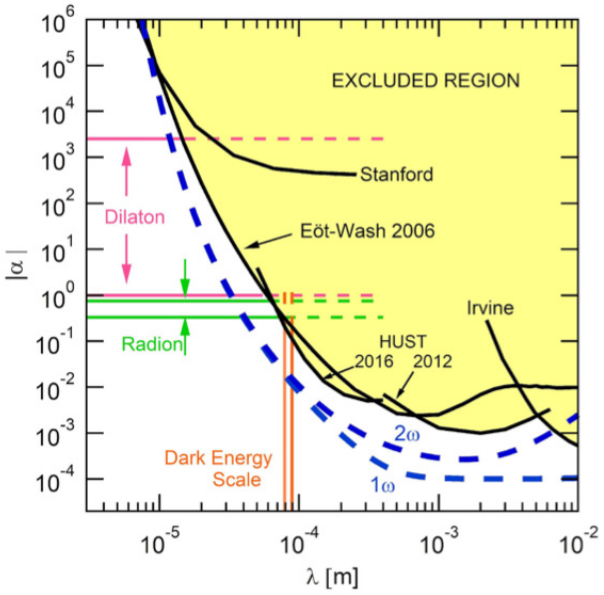

Figure 1: α - λ parameter space for ISL deviations. Black curves correspond to previous experiments' limits [5,6] while the blue dashed curves correspond to the projected sensitivity of the Humboldt experiment [7]. The yellow region is the region where there are no deviations from the ISL within 95% confidence. The dilaton, radion, and dark energy scale regions correspond to various theoretical situations that call for certain parameter ranges, as described in Reference [8].

1.3 Weak Equivalence Principle Tests

The weak equivalence principle (WEP) can be stated as "the gravitational force felt by an object is independent of its composition." The WEP is a central tenet of General Relativity. WEP violations can be parameterized by assuming a fifth force of nature that is related to some linear combination of the baryon and lepton numbers. This fifth force would couple to a "charge" $\tilde{q}$, that can be parameterized by:

$$\tilde{q} = \tilde{g}[Z\cos(\tilde{\psi}) + N\sin(\tilde{\psi})], \quad (2)$$

where Z and N are the atomic number and neutron number, respectively, of the material in question and $\tilde{g}$ is a coupling constant. Note that this is easily transformed through the mixing angle, $\tilde{\psi}$, to the baryon number, B, and the lepton number, L, for an electrically neutral material by using the relations B=Z+N and L=Z. This coupling leads to a potential energy between two point masses of the form:

$$V(r) = -\frac{Gm_1m_2}{r}\left(1+\tilde{\alpha}\left[\frac{\tilde{q}}{\tilde{g}\mu}\right]_1\left[\frac{\tilde{q}}{\tilde{g}\mu}\right]_2 e^{-r/\lambda}\right), \quad (3)$$

where μ is the mass in atomic mass units (u), $\tilde{q}$ is the fifth force "charge" as described above, $\tilde{g}$ is a coupling constant, λ is the Compton wavelength of the fifth force exchange boson, and $\tilde{\alpha} = \pm\tilde{g}^2/(4\pi Gu^2)$ (+ and - for scalar and vector coupling, respectively). The quantities inside the brackets are of object 1 and 2 as labeled. These parameters have had limits set on them by previous experiments, which are shown in Figure 2.

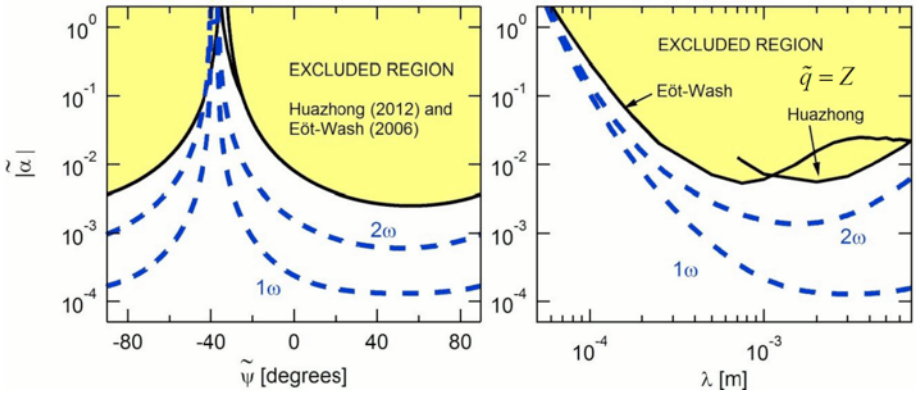

Figure 2: On the left is the $\tilde{\alpha}$ - $\tilde{\psi}$ parameter space, with λ = 1 mm, and on the right is the $\tilde{\alpha}$ - λ parameter space, with $\tilde{q}$ = Z, for the above WEP deviation potential. Black curves correspond to previous experiments' limits while the blue dashed curves correspond to the projected sensitives of the Humboldt experiment. [7]. The yellow region is the region where there are no deviations from the WEP within 95% confidence.

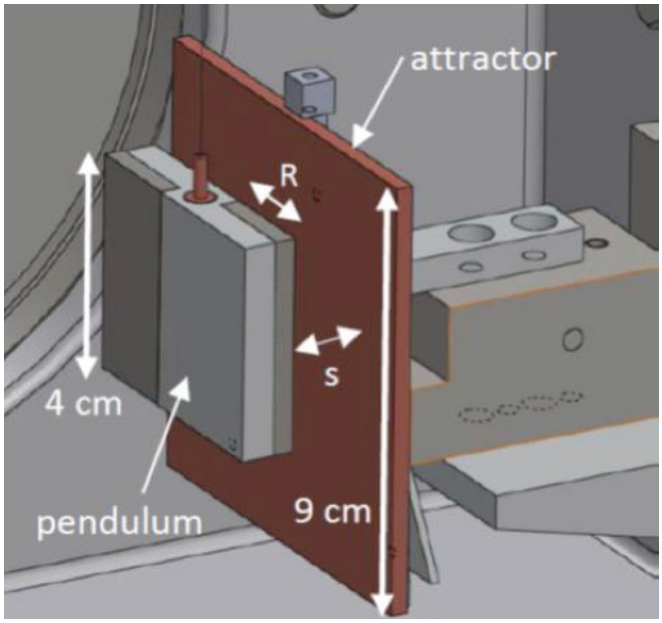

Figure 3: Pendulum-Attractor Geometry. The copper plate is the attractor mass held rigidly to the stage of a stepper motor. This facilitates the oscillatory motion. Just in front of the attractor is the suspended pendulum. The lighter gray section is aluminum while the dark gray is titanium. Not shown is a 25μm thick BeCu electrostatic shield which will be stretched in between the attractor and the pendulum.

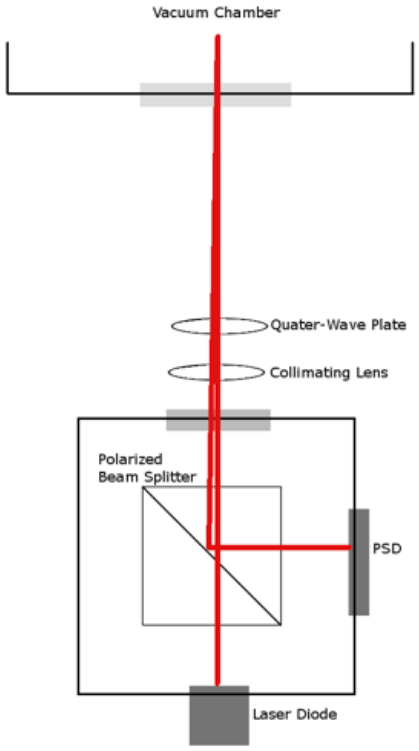

Figure 4: Autocollimator Schematic. This system was built and tested on a benchtop optical table before installation [9]. Noise tests of the system found the noise floor at 0.01 Hz, the frequency of interest in the Humboldt experiment, to be about 1.0×10^{-7} $rad/\sqrt{Hz}$ which corresponds to a nanoradian sensitivity in about 4 hours [9]. This performance exceeded the requirements and the system was subsequently implemented onto the apparatus.

2. Experiment Overview

At Humboldt State, an experiment is being constructed that will probe the WEP and ISL at untested length scales for a given deviation strength. The experiment consists of a rectangular torsion pendulum in close proximity to a rectangular plate attractor mass, shown in Figure 3. This copper attractor mass is modulated toward and away from the pendulum, thus inducing a time-varying torque on the pendulum. The motion of the pendulum is recorded using an optical system described in Section 2.1. The pendulum consists of an aluminum step with two titanium blocks attached to each side, making a complete rectangular prism. The pendulum is hung using a 25μm diameter tungsten fiber. Due to the use of two different materials, the atomic number and neutron number of either side differs on the surface that faces the attractor. This design allows for tests of the WEP as described in Section 1.3.

2.1 Optical Measurement System

To meet expected sensitivities, an optical system able to measure angles to one nanoradian uncertainty per day is required. The angular uncertainty at a given frequency can be determined by:

$$\Delta\theta = \frac{A}{\sqrt{t}} \qquad (4)$$

where A is the noise floor at that frequency and t is the amount of time the angle is recorded. To achieve nanoradian uncertainty for a one-day data run, the noise floor would have to be less than 3×10^{-7} $rad/\sqrt{Hz}$ at the frequency of interest [9]. An autocollimator was designed and implemented with this goal in mind. It consists of a polarized laser beam directed through a polarized beam splitter, collimating lens, and a quarter wave plate before striking the pendulum and returning through a similar path. A schematic of the autocollimator is shown in Figure 4. The use of a polarizing beam splitter and a quarter-wave plate allow the system to distinguish between outgoing and incoming beams. The outgoing beam is originally linearly polarized such that it is transmitted through the beam-splitter. It is then circularly polarized at the quarter-wave plate, switches orientation when reflected off the pendulum, and then is linearly polarized when it returns to the quarter-wave plate. Due to the switched circularly polarized orientation, the returning beam is polarized perpendicularly to the outgoing beam

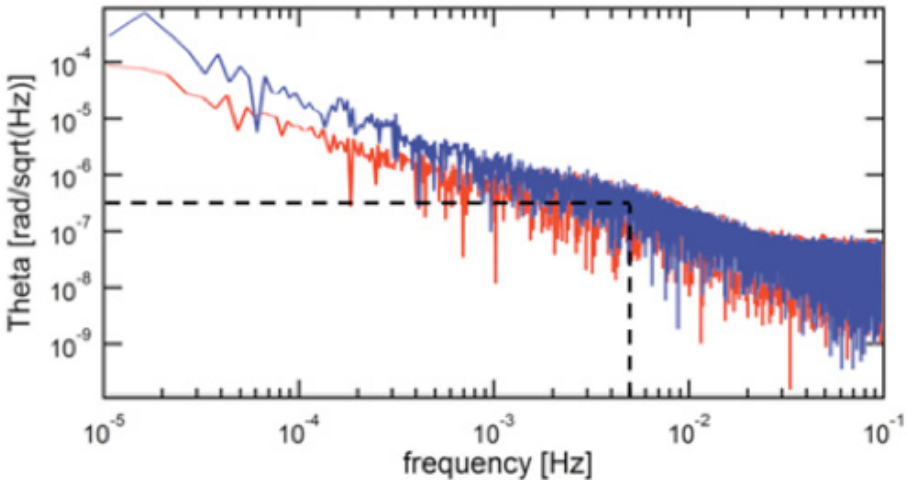

Figure 5: Autocollimator Benchtop Noise Tests. The red data is a noise run with the laser off while the blue is with the laser on. The black dashed line corresponds to the sensitivity requirements of the system. Figure taken from Reference [9].

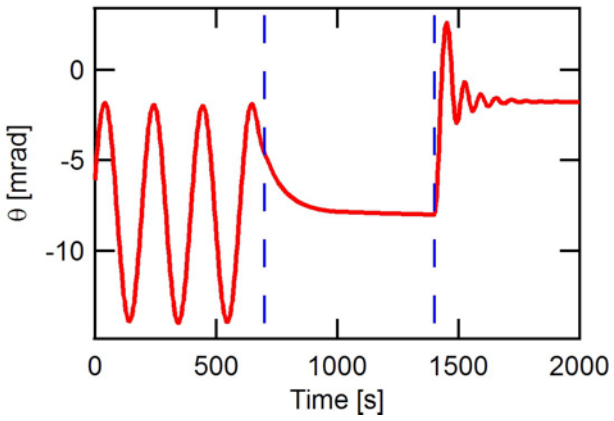

Figure 6: A demonstration of pendulum controls. At the time of the first dashed line, the electrode controls were turned on which subsequently damped out any motion of the pendulum. At the time of the second dashed line, the equilibrium position of the pendulum was shifted and the electrode system damped out the resultant motion.

causing it to reflect off of the beam-splitter and to a position sensitive device (PSD). The PSD outputs voltages for each of the four sides which correspond to the beam's position. These voltages are sent through an amplification circuit which outputs three signals: the difference between the two horizontal sides, the difference between the two vertical sides, and the sum of the two horizontal sides. These are then recorded using a LabVIEW data acquisition program. The ratio of the difference and the sum of the horizontal sides is proportional to the angle of the pendulum, allowing one to measure the angle of the pendulum over time.

2.2 Pendulum Control Systems

Due to the close proximity required for this experiment, the pendulum's free resonant motion and position must be well controlled prior to taking data.

2.2.1 Pendulum Positioning Assembly

To be able to make the measurements required for this experiment, the ability to translate the pendulum about the chamber and rotate the pendulum about its vertical axis is necessary. This is achieved using a translation stage which allows for three directional translations of the pendulum's connection point and a rotation stage which allows for rotations about the vertical axis. These controls allow the pendulum to be moved close to the attractor mass, aim the reflected beam back to the autocollimator, and manually damp unwanted motion of the pendulum.

2.2.2 Eddy Current Damper

The Humboldt experiment is only interested in the torsional motion of the pendulum, however, there are many other modes of motion that can influence the measurements. These include swing in both horizontal directions. To mitigate these effects, an eddy current damper was installed which consists of a pre-hanger fiber connected to an aluminum disk from which the pendulum is hung. The aluminum disk is suspended between the north and south poles of two separated ring magnets. This adds damping for any motion that is not uniform about the axis of the fiber due to the eddy currents caused by the change of magnetic flux through the aluminum disk.

2.2.3 Electrode Control

The thinness of the fiber causes the pendulum to react drastically to any shock or twist that may happen while work is done on or around the chamber. The pendulum will have a large quality factor due to various environmental controls, described in Section 2.3.1. Because of this, an electrode control system was developed which applies damping torques to the pendulum in order to decrease the amplitude before taking data. The system consists of two rectangular electrodes positioned in close proximity to the pendulum on the opposite side from the attractor mass. Voltages are applied based on PID feedback from the autocollimator's angular signal. The PID loop is controlled using a LabVIEW program allowing for manual changing of the PID parameters.

2.3 Environmental Effects

The sensitivity of these tests requires a very low noise apparatus. Thus, many efforts to decrease environmental noise sources have been or will be implemented.

2.3.1 Vacuum System

The pendulum and attractor mass are both placed inside a rectangular freestanding vacuum chamber. This is pumped down to ~10^{-6} Torr via a turbo pump, which stops any convection currents inside the chamber and decreases the heat conduction pathways from the walls of the chamber to the pendulum. Being at ultra-high vacuum also decreases gas damping of the pendulum thus increasing the pendulum's quality factor to approximately 3500.

2.3.2 Electrostatic Shielding

The pendulum is gold-coated and the pendulum-fiber assembly is surrounded by electrostatic shielding, which decreases both electrostatic coupling and patch charge build up. Any electrostatic coupling would overpower gravitational signals due to the dramatic difference in strength between the two forces.

2.3.3 Thermal Controls

Due to the thinness of the tungsten fiber, any temperature fluctuations of the fiber will produce a torque on the pendulum. To decrease these effects, many steps have been taken to stabilize the temperature of the fiber. The shielding that surrounds the fiber has a large mass, thus decreasing any high frequency coupling to temperature fluctuations of the walls. The entire chamber is placed inside a large thermal isolation box which has its temperature controlled to within 10 mK, thus decreasing low-frequency temperature

fluctuations. Multiple temperature sensors are placed throughout the room and within the chamber to monitor the temperature while the experiment is running [10].

2.3.4 Magnetic Measurements

The ambient magnetic field in the experiment is not well controlled. To account for this, the magnetic moment of the pendulum in the horizontal plane was measured by applying a time varying magnetic field to the chamber and measuring the pendulum's response. Using this, the torque that would be caused by a normal varying of the earth's magnetic field was calculated and found this to be below the autocollimator's noise limit [10].

2.3.5 Tilt Compensation System

Although the pendulum always hangs along the local vertical axis, the chamber, and thus the optical systems, can tilt along both horizontal directions. Such a tilt would be indistinguishable from tilt of the pendulum. To account for this, there are tilt sensors, one for each direction, placed on top of the chamber. A feedback system which extends the legs of the chamber by thermal expansion to decrease tilt is currently being developed.

In order to compensate for this, and any other tilt the apparatus may experience, a system is being designed which will read tilt information from tilt sensors placed on top of the apparatus and applies heat to the three legs of the apparatus to compensate for this tilt. Figure 7 shows the tilts that the apparatus experiences over the course of 4.5 days with the tilt compensation system turned on and off. The system currently decreases the tilts by roughly a factor of two, which was found to be an acceptable level of compensation, and will be improved upon in future work.

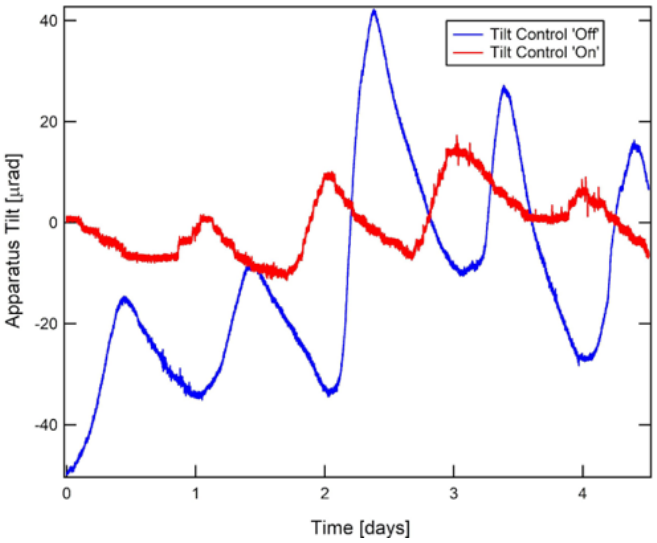

Figure 7: Time series of measured chamber tilt with tilt compensation system turned on (red) and off (blue). The tilt control system decreases apparatus tilts by roughly a factor of two.

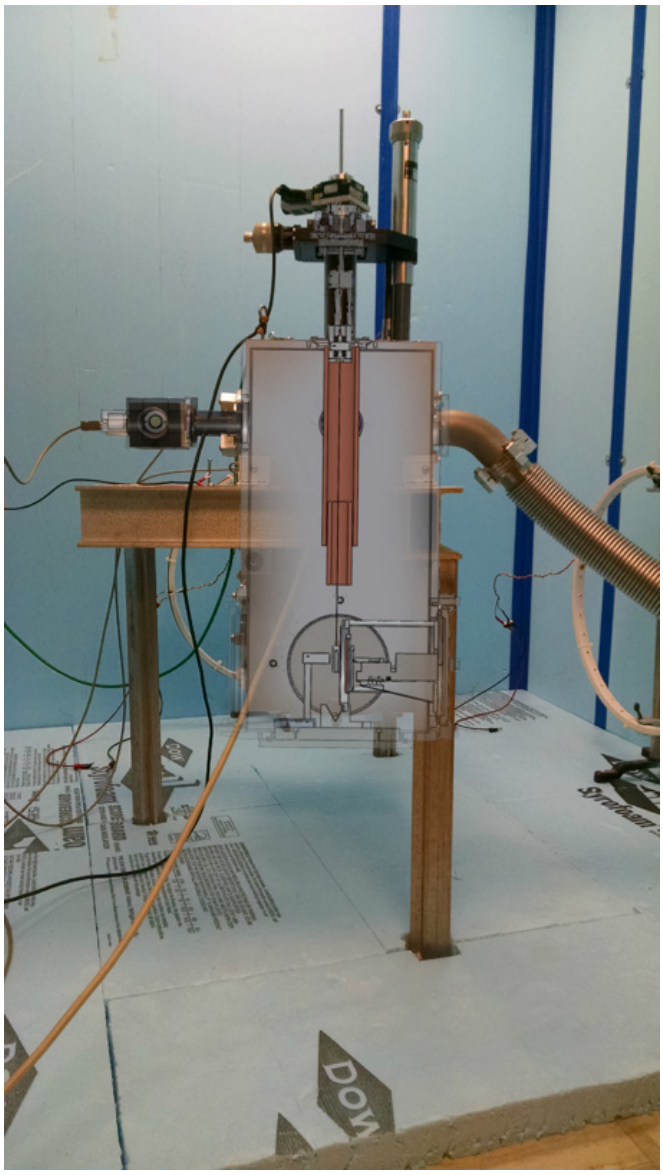

Figure 8: A cross section of the designs for the apparatus overlaid onto a picture of the vacuum chamber. The black box on the left of the chamber is the autocollimator. On the top is the pendulum positioning assembly and eddy current damper. At the bottom of the chamber is the electrode control system, pendulum, and attractor mass assembly.

3. Signal Processing and Data Analysis

Data recorded by the acquisition program is analyzed using a custom python script. Recent upgrades to the analysis software have placed the experiment in a position where preliminary data can be fully analyzed.

3.1 Converting the autocollimator output to a twist angle

The PSD output voltages are used to determine the pendulum's twist by

$$\theta = c_1\left(\frac{\Delta_s}{\Sigma}\right) + c_2\left(\frac{\Delta_s}{\Sigma}\right)^2, \qquad (5)$$

where Δ_s is the voltage proportional to the difference between the two horizontal sides and Σ is the voltage proportional to the sum of the two horizontal sides of the PSD. The linear and quadratic calibration coefficients c_1 and c_2 can be determined by remotely adjusting the rotation stage by a known

angle and comparing the new equilibrium to the autocollimator output. We found

$$c_1 = 1.0351^\circ \pm 0.00505^\circ.$$

Data was recently taken to determine c_2. However, this data was shown to be inconsistent. Unfortunately, the apparatus was taken out of vacuum before additional tests were done. Furthermore, upon opening the apparatus, it was found that the pendulum had a slight but noticeable tilt so that it did not hang perpendicular to the incident beam. In response, work is being done to distinguish potential problems that might impede future determination of the coefficient.

3.2 Filtering out the free oscillations

Because the pendulum's free oscillation provides no information about the ISL or WEP, a digital filter is utilized to suppress this signal before analyzing the attractor effects. This "torsion filter" assigns a new value

$$\theta_f(t) = \frac{1}{2}\left[\theta\left(t - \frac{\tau_0}{4}\right) + \theta\left(t + \frac{\tau_0}{4}\right)\right] A_f, \quad (6)$$

to a data point by averaging two data points a quarter of a torsion period on either side, where τ_0 is the period of the pendulum's free oscillation (about 350 seconds) and θ is the interpolated value of the twist.

The digital filter described inherently affects the attractor signal in addition to the pendulum's free oscillation. To account for this, the term below is applied

$$A_f = sec\left(\frac{\pi\omega}{2\Omega}\right), \quad (7)$$

where ω is the attractor mass frequency and $\Omega = \frac{2\pi}{\tau_0}$, that restores the signal of interest. An example of the effectiveness of the filter is shown in Figure 10.

3.3 Analysis of the twist data

The data is subdivided into many "cuts" containing an arbitrary integer number of oscillations of the attractor mass. It was found that fourteen oscillations (about 2800 seconds) worked well for preliminary data runs. For each cut, θ_f is fitted as a function of time with

$$\theta_{th}(t) = \sum_n [b_n sin(n\omega t) + c_n cos(n\omega t)] + \alpha + \beta t, \quad (8)$$

where the sum accounts for multiple harmonics and α and β account for fiber drift. A "chi-squared" statistic can be computed

$$\tilde{\chi}^2 = \sum_{i=1}^{N_d} (\theta_f(t_i) - \theta_{th}(t_i))^2, \quad (9)$$

where N_d is the number of points contained in a cut, that reflects the goodness of the fit. Based on the $\tilde{\chi}^2$ distribution, as shown in Figure 11, and other criterion, one can reject specific cuts that are dominated by environmental disturbances before inferring the torque applied on the pendulum.

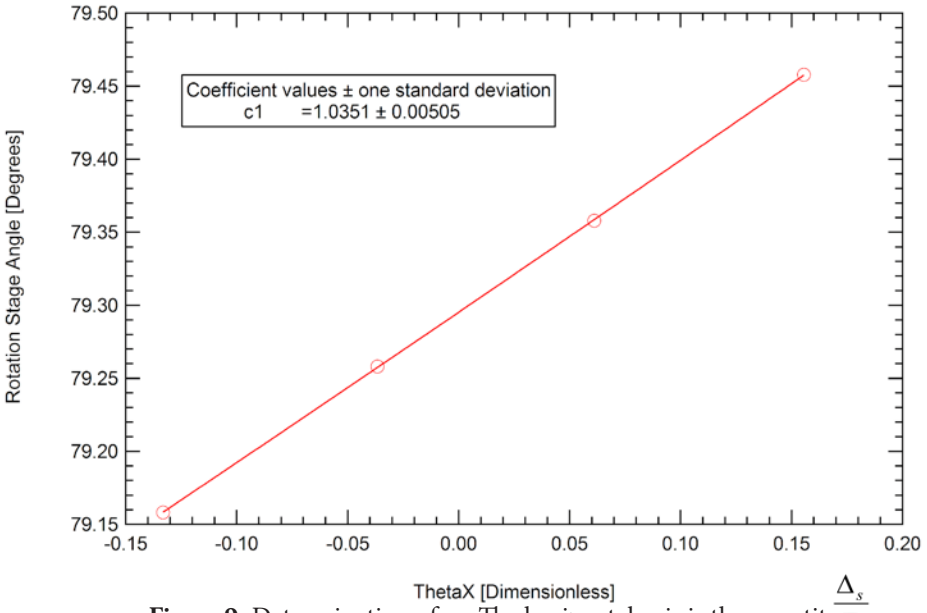

Figure 9: Determination of c_1. The horizontal axis is the quantity $\frac{\Delta_s}{\Sigma}$.

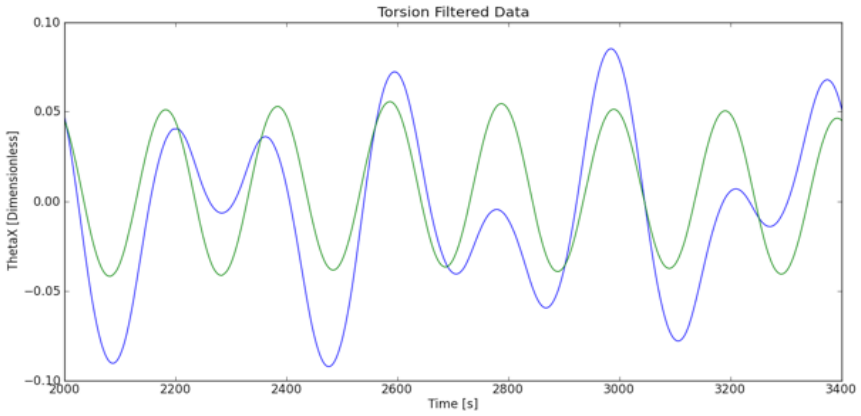

Figure 10: Torsion filtered data. The blue curve corresponds to raw data, while the green curve is data with the pendulum's free oscillation filtered out. The vertical axis is the quantity $\frac{\Delta_s}{\Sigma}$ described in section 3.1.

For all N_c cuts that survive the rejection criterion, the mean and standard deviation of the b_n coefficients can be calculated as

$$\overline{b_n} = \frac{1}{N_c}\sum_{i=1}^{N_c} b_n(i); \sigma_{\overline{b_n}} = \sqrt{\frac{1}{N_c(N_c-1)}\sum_{i=1}^{N_c}(b_n(i) - \overline{b_n})^2}, \quad (10)$$

with similar equations applying to the c_n coefficients. The applied torque on the pendulum, N, can then be found with

$$N = \kappa\theta f_i, \quad (11)$$

where κ is the torsional spring constant of the fiber and $f_i = A_i e^{i\Phi_i}$, which accounts for the effects of pendulum inertia, where

$$A_i = \sqrt{[1-(\omega/\Omega)^2]^2 + (1/Q)^2};$$

$$\Phi_i = tan^{-1}\frac{\Omega^2}{Q(\Omega^2 - \omega^2)}, \quad (12)$$

and Q is the quality factor of the torsion oscillator [5].

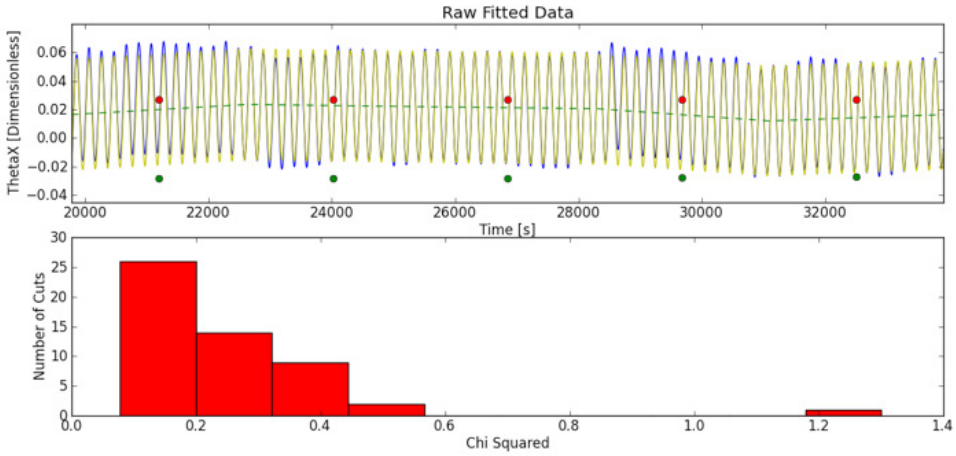

Figure 11: Fitted data for the 1ω signal. Top plot: 5 cuts of length 2826 seconds. The blue curve corresponds to θ_f, while the yellow curve is θ_{th}. The green and red circles are the b_n and c_n coefficients respectively. The green dashed line corresponds to the polynomial $\alpha + \beta t$. Bottom plot: a typical "chi squared" distribution. For this distribution, the cut whose $\tilde{\chi}^2$ is above the 1.0 bin would most likely be rejected based upon correlation with an environmental disturbance identified with other sensors; all other cuts are reasonable since they have $\tilde{\chi}^2$ of order less than 1.

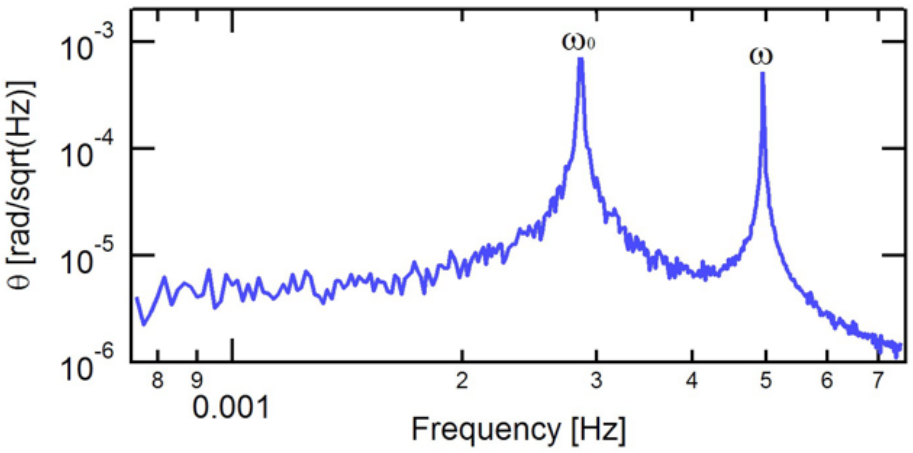

Figure 12: A section of the amplitude spectral density of the pendulum's motion. ω_0 is the natural frequency of the pendulum and ω is the frequency of oscillation of the attractor mass.

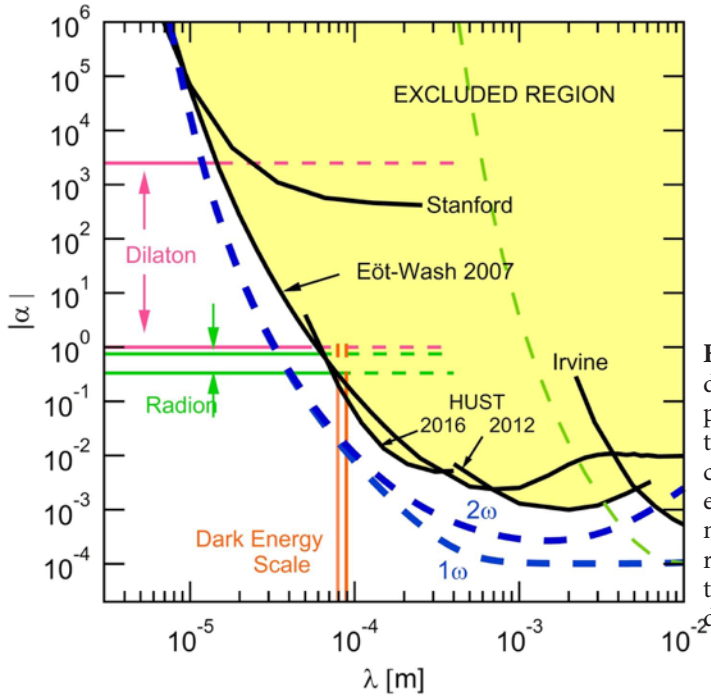

Figure 13: α - λ parameter space for ISL deviations. The green dash curve is preliminary limits from recent runs with minimum pendulum-attractor separation of 8 mm. Black curves correspond to previous experiments' limits [5,6] while the blue dashed curves correspond to the projected sensitivity of the Humboldt experiment [7]. The yellow region is the region where there are no deviations from the ISL within 95% confidence. The dilaton, radion, and dark energy scale regions correspond to various theoretical situations that call for certain parameter ranges, as described in Reference [8]

4. Preliminary Data

Recent updates, as discussed above, have brought the experiment to a point where the data may contain gravitational information. Data has recently been taken which appears to be of improved quality over other runs. This data has not yet been analyzed to the point where one could say if there is any gravitational information, but the current phase of analysis is relevant nonetheless.

4.1 Attractor mass run

Data taken in 2015 includes an attractor mass run in which the attractor mass was driven at a frequency of 5 mHz and with an amplitude of 1 mm. Figure 12 is a section of the amplitude spectral density of this attractor mass run. In this figure, ω_0 is the frequency of the natural oscillation of the pendulum, while ω is the frequency of the attractor mass oscillation. This data clearly indicates some interaction between the attractor mass and pendulum, however, whether this is due to gravity or other forces has yet to be determined.

The above spectrum exhibits the ability to operate a torsion balance while modulating the attractor mass without broadband noise injection. With future systematic studies and improvements, non-gravitational coupling paths between the attractor and pendulum can be rejected while also decreasing the noise and environmental effects.

4.2 Preliminary Limits

With the ability to resolve interactions between the attractor and pendulum, preliminary limits can be set on ISL violations which are shown in Figure 13. These limits were obtained using data with pendulum-to-attractor separation of 8 mm and are only an estimate due to unconstrained systematics that are currently being investigated. With improved systemic understanding and smaller pendulum-attractor separations, the limits are expected to reach to lower λ scales and approach the experiment's design sensitivity.

Conclusion

At Humboldt State, an apparatus has been constructed that can controllably measure the interactions between a torsion pendulum and an attractor mass. This apparatus has the promise to test both the Inverse-Square Law and the Weak Equivalence Principle at unprecedented length scales and has begun to set preliminary limits on Inverse Square Law violations. With continued systematic understanding and experimental control, these limits are expected to approach the experiments design sensitivity which will increase the understanding of gravitational interactions in novel regimes.

Acknowledgements

We are thankful for financial support from the National Science Foundation (Grants PHY-1065697, PHY-1306783, and PHY-1606988), Research Corporation (Cottrell College Science Award CC6839), and the Humboldt State University College of Natural Resources and Sciences (CNRS), Office of Research and Graduate Studies, and President's Office. Special thanks to Dr. C.D. Hoyle for the mentoring and guidance.

References

1 S. Dimopoulos, N. Arkani-Hamed, and G.R. Dvali. "The hierarchy problem and new dimensions at a millimeter." Phys. Lett. B, 429:263–272, 1998.

2 S. Dimopoulos, N. Arkani-Hamed, and G.R. Dvali. "New dimensions at a millimeter to a fermi and superstrings at a tev." Phys. Lett. B, 436:257, 1998.

3 M. Kolanovic, G. Dvali, G. Gabadadze, and F. Nitti. "Scales of gravity." Phys. Rev. D, 65:024031, 2001.

4 Jiro Murata and Saki Tanaka, "A review of short-range gravity experiments in the LHC era," Class. Quantum Grav. 32 033001, 2015.

5 C. D. Hoyle, D. J. Kapner, B. R. Heckel, E. G. Adelberger, J. H. Gundlach, U. Schmidt, and H. E. Swanson. "Submillimeter tests of the gravitational inverse-square law." Phys. Rev. D, 70:042004, Aug 2004.

6 Wen-Hai Tan, Shan-Qing Yang, Cheng-Gang Shao, Jia Li, An-Bin Du, Bi-Fu Zhan, Qing-Lan Wang, Peng-Shun Luo, Liang-Cheng Tu, and Jun Luo. "New Test of the Gravitational Inverse-Square Law at the Submillimeter Range with Dual Modulation and Compensation." Phys. Rev. Lett. 116, 131101, 2016.

7 David W. Shook. "Experimental tests of gravity below the 50-micron distance scale." Proceedings of The National Conference On Undergraduate Research (NCUR), 2010.

8 Holly Leopardi, and David Smith. "Short-range tests of gravitational physics." Proceedings of The National Conference On Undergraduate Research (NCUR), pages 178–186, 2013.

9 Holly Leopardi. "Tests of gravity below fifty microns." Proceedings of The National Conference On Undergraduate Research (NCUR), pages 357–162, 2012.

10 Andrew C. Harter. Crystal Cardenas, and Michael P. Ross. "Experimental progress on tests of gravity at 20 microns." Proceedings of The National Conference On Undergraduate Research (NCUR), pages 811–819, 2014.

Assessing the Ability of Incipient Basaltic Soil to Support Plants Native to Southwestern United States

By Antonia L. Jim[1], Aditi Sengupta, Ph.D[2#]

[1]Fort Lewis College, Durango, CO, [2] Biosphere 2, University of Arizona, Tucson, AZ

[#] Current Address: Pacific Northwest National Laboratory, Richland Washington; Email: aditi.sengupta@pnnl.gov

Abstract

Intense agricultural practices, overgrazing, deforestation, growing population rates, and climate variability are cumulatively contributing to soil depletion globally. It is therefore necessary to evaluate and improve the capacity of marginal soils to support plant growth. In this study, lithogenic basalt soil gathered from Merriam Crater in Northern Arizona was utilized as a marginal soil material to test its capacity in supporting plant growth with or without soil amendments. A month-long greenhouse experiment was conducted to determine the growth response of three plant species (Panicum Sonorum, Prosopis spp, and Tarahumara Norteño) in basalt soil. These species, native to the Arizona-Sonora region, typically grow in arid to semi-arid environments, are very heat tolerant, and can retain water. Three treatments were established: parent material, parent material + 20% compost, and potting soil with three replicates of each species (n=27). Plant-growth supporting capacity was evaluated by measuring vegetative parameters including percentage germination, plant height, and dry/wet aboveground biomass. Potting soil significantly ($p<0.05$) supported more plant growth over the other two treatments, irrespective of species. Compost-amended soil supported slightly greater plant growth than the parent material alone, but this difference was not significant ($p < 0.05$). Overall, this study determined that marginal basaltic soil is capable of plant growth with the results suggesting vegetation choices on soils of similar type in the future.

Introduction

Transformation of rock to plant-sustaining soil occurs over hundreds of years, with 500-1000 years required to form an inch of fertile top soil.[1] However, top soil is being lost at increasing rates, with an estimated 6.9 billion tons lost every year in the United States alone.[2] Intense agricultural practices, overgrazing, deforestation, growing population rates, and climate variability are cumulatively contributing to soil depletion, resulting in food insecurity. The Food and Agriculture Organization (FAO) has reported that one-third of the world's soil has already been lost with an estimated 60 years of arable land left.[3] On average in the US, soil is depleting twenty times faster than it is forming.[4,5] It is therefore necessary to evaluate the capacity of marginal soils to serve as non-traditional sources of soil to support plant growth. Marginal soils can include incipient soils, soils affected by mining processes and fire, over-used agricultural lands, vacant urban plots, and primary succession ecosystems. While not all marginal soils will support food crops, soils that are able to support plant cover will prove beneficial for natural ecosystems. Effective vegetation on such marginal soils may benefit from sowing native seeds that are adapted to local climatic regimes and soil types.[6] Additionally, historical data available from seed banks can provide observational evidence of cultivation conditions best suited to local combinations of soil and climate.[7] This approach can support crop conservation and biodiversity, and help promote cultural heritage preservation.

Lithogenic incipient materials have been known to support plant growth, and, in turn, undergo weathering processes. A study by Burghela et al. in 2015 examined lithogenic weathering of four different rock types (granite, rhyolite, basalt, and schist) amended with arbuscular mycorrhizal fungi (AMF) to examine mineral nutrient mobilization by buffalo grass. Results showed that mineral weathering and nutrient release were enhanced in the presence of plants, with an overall increase in plants associated with AMF.[8] In another study, revegetation of acid mine tailings was evaluated using AMF, *Prosopis*, and compost amendments. The results showed that AMF-inoculated plants had higher dry biomass and root length when compared to controls grown in uninoculated compost-amended tailings.[9] A third study applied natural amendments to marginal soils on the Falkland Islands to examine revegetation of eroded soils.[6] These studies provide evidence of marginal soils' ability to support plant growth. The goal of this study was to evaluate the growth of native Arizona and Sonora plant species without any biological amendments. This study fills a critical gap in understanding the capacity of lithogenic incipient basalt material to support plant growth.

A month-long greenhouse experiment was conducted to determine the growth response of three seed types when grown in basalt soil. These seed types included the species *Panicum sonorum* (Panic Grass), *Prosopis spp.* (*Prosopis*), and *Phaseolus vulgaris* "Tarahumara Norteño" (Common Bean). *P. Sonorum* prefers soil that has been well-drained and can also grow in nutritionally poor soil. This plant is believed to have been discovered in Arizona and Sonora thousands of years ago and was cultivated in Hohokam dating back to four thousand years ago. If well irrigated, *P. Sonorum* grows rapidly, is heat tolerant, and is dependent on annual flooding to germinate.[7] *Prosopis spp.,* also known as mesquite, grows in arid and semi-arid environments such as deserts, woodlands, floodplains, grasslands, and shrublands. *Prosopis* can retain soil moisture, have deep tap roots and leaf adaptations to reduce water loss that allow them to access the water table in

arid environments, and have the ability to host nitrogen-fixing bacteria in their root nodules.[10] *Prosopis* are considered invasive in subtropical and tropical regions globally, although in its native setting, the plant increases vegetation cover. The *Tarahumara Norteño* bean originated in the Tarahumara area of the Chihuahua region in Mexico and has been widely cultivated by Native American farmers throughout the Southwest.[7,11] *T. Norteño* are known to grow in semi-tropical regions and host nitrogen-fixing bacteria in their root nodules.

These three species typically grow in arid to semi-arid environments, are heat tolerant, and can retain water. The grass and bean seeds were sourced from Native Seeds in Tucson, AZ, and *Prosopis* seeds were sourced from Desert Nursery in Phoenix, AZ. Given the time limitation (30 days) of this pilot project, the plant species were selected to suit the high summer (June-July 2017) temperatures of Southwest Arizona and had short germination periods. Three treatments were used: basalt parent material, parent material amended with compost, and potting soil. The objectives were to evaluate the ability of incipient basaltic soil to support native plant growth, determine whether treating the soil with compost would enhance plant establishment and growth, and evaluate differences in growth in potting soil versus incipient soil.

Methods

Experimental Design

Lithogenic basalt soil gathered from Merriam Crater in Northern Arizona was utilized as an incipient soil material. This basalt soil is being extensively studied at the Landscape Evolution Observatory (LEO), housed at the University of Arizona Biosphere 2 complex, to understand coupled hydrobiogeochemical processes of landscape evolution.[12,13] While the basalt landscapes are currently bare, there are plans to introduce plants to the soil system to understand how vegetation affects landscape evolution of incipient soils. This current study stands to inform future research directions of vegetating the LEO hillslopes.

A greenhouse pot experiment was conducted with three species (*P. Sonorum, Prosopis*, and *T. Norteño*) and three soil materials: basaltic parent material from the LEO experiment (LPM), LEO parent material + 20% w/w commercially available compost (LPMC), and commercially available potting soil (PS). Compost was added to evaluate the effect of a natural amendment on LPM's capacity to support plant growth while potting soil served as a positive control. Three replicates were set up for each species-soil material combination (n=27) in 1-gallon plastic pots with 2.1 kg LPM, 2.1 kg (1.68 kg LPM + 0.42 kg compost) LPMC, and 0.6 kg PS. The pots were arranged in a randomized complete block design with ten seeds sown per pot (Figure 1a). *Prosopis* seeds were soaked for 24 hours to remove seed husks. The bean seeds were planted 1 cm below the surface and the grass seeds were loosely covered by soil material. All pots were covered with a square mesh tarp for shade and to reduce impact of irrigation on the seeds. A drip irrigation system was set to increments of three one-minute events a day at 8:30 a.m., 12:00 p.m., and 4:30 p.m., respectively, for seven days a week totaling 720 ml/day of tap water per pot. The irrigation rate was determined after observing the maximum volume of water the pots could hold without water pooling on the surface. The pots were monitored for 30 days (June 24-July 24, 2017) under natural temperature and light conditions.

Monitoring

To assess the effectiveness of soils in supporting plant growth, pots were surveyed every week. Percent germination was recorded after 10 days, while plant height was recorded every week. Percentage seed germination was determined by the number of visible plant stems in each pot 10 days after planting. One individual plant in each pot was marked and observed continuously for consistent measurements. Plant height measurements (cm) were recorded at weekly intervals, with height measurements observed on the final day used for statistical comparisons. On the 30th day (Figure 1b), plants were harvested, and wet and dry above-ground biomass of the plant was recorded. Wet above-ground biomass samples were weighed on a balance scale, followed by oven drying the samples at 65°C for 48 hours and then reweighing to determine dry above-ground biomass.

Statistical Analysis

Percent germination, plant height, and wet and dry above-ground biomass were analyzed using JMP® 13.0. Significant mean differences were determined by one-way ANOVA ($p < 0.05$) with post-hoc pairwise comparisons of the means among soil types within each plant species using Student's *t*-test at a significance level of $p < 0.05$.

Results and Discussion

Percent Germination

Significant differences in germination were observed for the bean plants, with 50% germination rates in potting soil in contrast to 10-18% observed in the par-

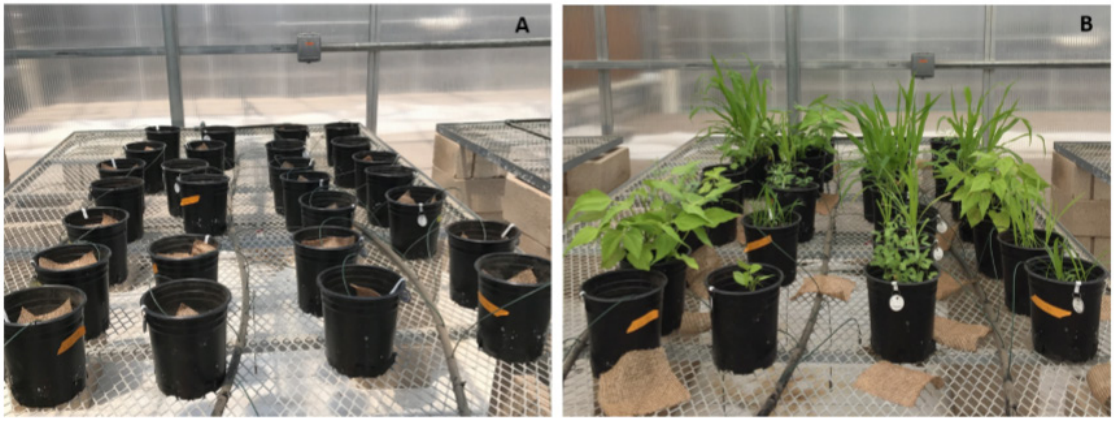

Figure 1: Greenhouse experimental set-up: (a) Pre-germination, (b) 30 days post-germination

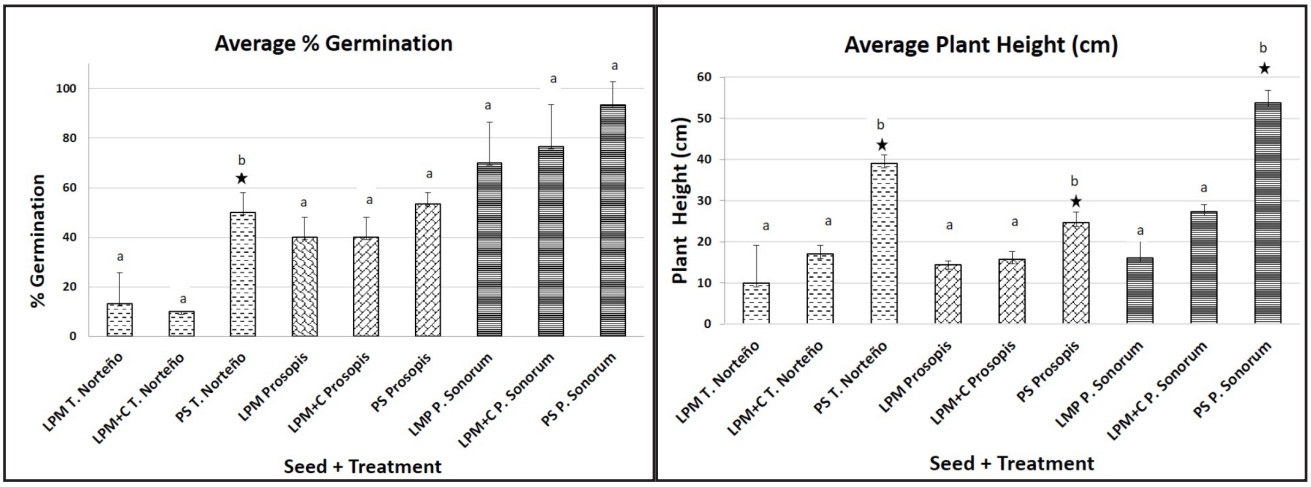

Figure 2: a) Average percent germination, and b) Average plant height of three species native to the southwest US—*T. Norteño*, *Prosopis,* and *P. Sonorum*—grown in 3 types of soil. (LPM = basaltic parent material, LPM+C = basaltic parent material plus compost, and PS = potting soil). Letters above the bars indicate significant differences ($p<0.05$) among soil types within a plant species.

ent material with and without compost amendment (Figure 2a). Significant differences in germination were not observed among any the soil treatments for *Prosopis* and *P. Sonorum*. An irregularity presented itself in one of the bean plant replicates in both LPM and LPMC due to malfunctioning irrigation drips that prevented the flow of water. This malfunction was observed on the last day of the study and could possibly explain low germination rates for the bean plants in basalt soil and basalt amended with compost. We infer that if irrigation drips had not malfunctioned, we would have observed comparable germination for the bean seed in PS, LPM, and LPMC soils, thereby concluding that all soil treatments can support germination without any significant effects.

Plant Height

For each species, significantly higher plant growth was observed for seeds planted in the potting soil as compared to basalt soil and basalt soil amended with compost (Figure 2b). The *P. Sonorum* and *T. Norteño* plants grew twice the height in the potting soil as compared to basalt with and without amendments, while overall growth was slower for the *Prosopis*. However, we highlight the ability of basalt parent material to support all three species with sustained growth observed. Despite shorter plant height for all three species, this result highlights the capacity of LEO parent material to support plants native to the Southwest region.

Above-ground biomass

Significant above-ground biomass accumulation was observed for bean and grass plants grown in potting soil. *Prosopis* plant accumulated the lowest biomass without any significant differences observed in any of the three treatments. The trends observed were similar for both wet and dry biomass measurements (Figure 3). The addition of compost to basalt soil did not significantly affect above-ground biomass when compared to basalt parent material alone. However, it is likely plants may need more than 30 days for significant changes to occur. Since incipient soils often lack necessary nutrients and organic matter to support plant growth, supplementing the soil with organic matter amendments may sustain plant growth, although the effects may not occur on a short time-scale.

Conclusions

This pilot study of assessing the ability of incipient basaltic soil to support plants showed that incipient basaltic material supports native plant germination of woody species with taproots (*Prosopis*) as well as herbaceous species with fibrous (*P. Sonorum*) and densely branched (*T. Norteño*) root systems. Additionally, germination occurred across all treatments, with potting soil significantly supporting higher plant growth when compared to the other two treatments. For the treatments with LEO parent material, no significant differences were observed between amended and non-amended soils. However, it may take a time frame of over 30 days to observe differences in growth between the compost amended soil and the parent material.

Future Work

Future work of this experiment includes characterization of bulk soil samples for physicochemical soil analyses such as bulk density, pH, electrical conductivity, carbon and nitrogen content, and elemental analyses of soil solution to determine edaphic variables that may cause differences in germination and plant growth. Additionally, rhizosphere soil collected from each plant's root zone will be evaluated for microbial community composition. Root zones are known to host plant-growth promoting rhizobacteria that are able to suppress plant pathogens and stimulate plant growth.[14] Establishing a baseline of such microorganisms in incipient soil-root systems will inform potential microbe-mediated vegetation strategies of marginal soils.

This pilot greenhouse study provides multiple research questions for future studies. These include examining sustained plant growth in the same soil treatments alongside multiple variations of the current experimental plan. For example, compost amendments can be varied, as well as different sources of natural amendments applied to the marginal soils. Additional variations for the basaltic soil can include changing irrigation regimes to test for plants that can withstand growth in arid or semi-arid conditions and testing diverse plant types. The results from such studies will be instrumental in informing vegetation choices on the LEO hillslopes in the future and guiding marginal soil revegetation strategies.

Acknowledgements

AJ would like to acknowledge support from the National Science Foundation through CIAN grant #EEC-0812072 and CIAN REU site award #EEC-1359163, and

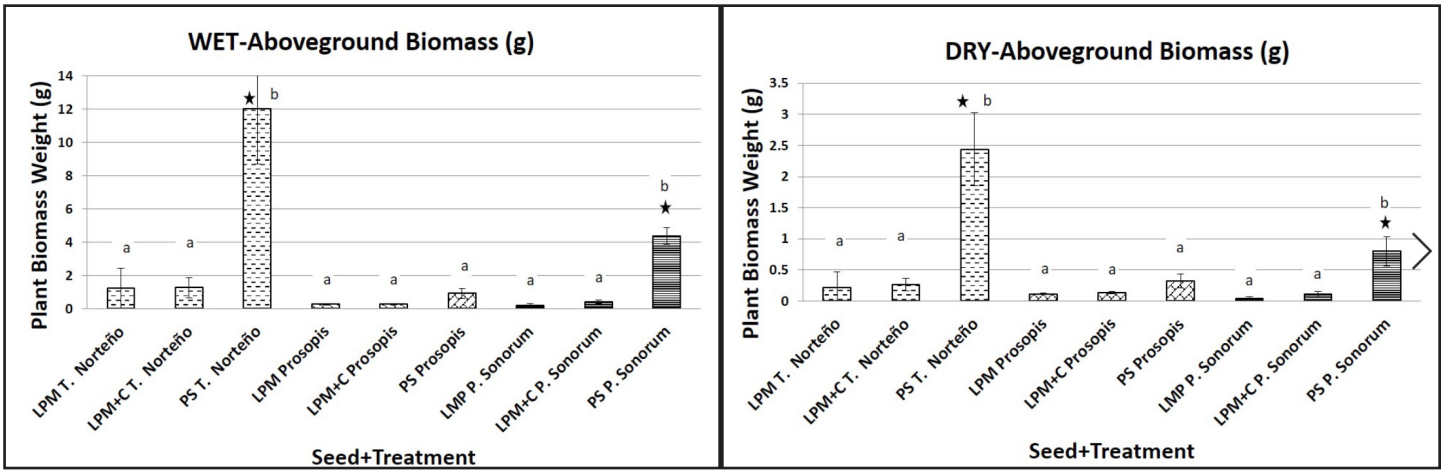

Figure 3: a) Average wet above ground biomass of three replicates, and b) Average dry above ground of three species native to the southwest US—*T. Norteño*, *Prosopis,* and *P. Sonorum*—grown in 3 types of soil. (LPM = basaltic parent material, LPM+C = basaltic parent material plus compost, and PS = potting soil). Letters above the bars indicate significant differences (P<0.05) among soil types within a plant species.

EEC-165910. AJ would also like to acknowledge IOU-NA-REU Program directors; Amee Hennig, Alison Hoff-Lohmeier and Emily Lynch for the opportunity to complete this research. AJ and AS thank the Environmental Microbiology Research Group of Dr. Raina M. Maier in the Department of Soil, Water and Environmental Science at University of Arizona for providing greenhouse support and access to lab equipment. AS would like to acknowledge Dr. Peter A. Troch and the Landscape Evolution Observatory team at Biosphere 2, University of Arizona for providing access to the soil material. AS would like to thank Emalee Eisenhower, Roopkamal Kaur, Katarena Matos, Genesis Matos, Antonio Alveres Meira Neto, and Scott Alexander White for their support during experimental set-up and sampling. AS and AJ also thank Dr. Katerina Dontsova and Dr. Kevin E. Bonine for facilitating Research Experience for Undergraduates (REU) program at University of Arizona. Lastly, AJ would like to thank her family, who supported her in this opportunity.

References

[1]Weil, R., and Brady, N. (2017) *The Nature and Properties of Soils*, *15th Ed.* Pearson Education Ltd.

[2]O'geen, A., and Schwankl, L. (2006) "Understanding Soil Erosion in Irrigated Agriculture Impacts of Soil Erosion." *University of California Agriculture and Natural Resources.* <http://anrcatalog.ucanr.edu/> (Accessed 07/28/2017)

[3]"Only 60 Years of Farming Left If Soil Degradation Continues." *Scientific American.* <https://www.scientificamerican.com/ > (Accessed 07/28/2017)

[4]Montgomery, D. (2007) "Soil erosion and agricultural sustainability." *Proceedings of the National Academy of Sciences of the United States of America.* 104.33. Pg 13268-13272.

[5]Pimentel, D. (2006) "Soil erosion: A food and environmental threat." *Environment, Development and Sustainability.* 8. Pg 119-137.

[6]Smith, S., Ross, K., Karlsson, S., Bond, B., Upson, R., and Davey, A. (2017) "Going native, going local: revegetating eroded soils on the Falkland Islands using native seeds and farmland waste." *Restoration Ecology*. 26.1. Pg 134-144.

[7]Native Seeds/SEARCH . <https://shop.nativeseeds.org/pages/seeds>(Accessed 07/11/2017)

[8]Burghelea, C., Zaharescu, D., Dontsova, K., Maier, R., Huxman, T., and Chorover, J. (2015) "Mineral nutrient mobilization by plants from rock: Influence of rock type and arbuscular mycorrhiza." *Biogeochemistry.* 124,1-3. Pg 187-203.

[9]Solís-Domínguez, F., Valentín-Vargas, A., Chorover, J., and Maier, R. (2011) "Effect of arbuscular mycorrhizal fungi on plant biomass and the rhizosphere microbial community structure of *Prosopis* grown in acidic lead/zinc mine tailings." *Science of The Total Environment.* 409.6. Pg 1009-1016.

[10](2017) "Species profile: Prosopis juliflora." *Global Invasive Species Database*. <http://www.iucngisd.org/ > (Accessed 07/17/2017)

[11]Duke, J. (1998) "Phaseolus vulgaris L." *Purdue University Center for New Crops and Plant Products*. Purdue University. <https://www.hort.purdue.edu/ > (Accessed 07/17/2017)

[12]Pangle, L., DeLong, S. B., Abramson, N., Adams, J., Barron-Gafford, G. A., Breshears, D. D., Brooks, P.D., Chorover, J., Dietrich, W.E., Dontsova, K., Durcik, M., Espeleta, J., Ferre, T.P.A., Ferriere, R., Henderson, W., Hunt, E.A., Huxman, T.E., Millar, D., Murphy, B., Niu, G., Pavao-Zuckerman, M., Pelletier, J.D., Rasmussen, C., Ruiz, J., Saleska, S., Schaap, M., Sibayan, M., Troch, P.A, Tuller, M., Haren, J.V., Zeng, X. (2015) "The Landscape Evolution Observatory: A large-scale controllable infrastructure to study coupled Earth-surface processes." *Geomorphology.* 244. Pg 190-203.

[13]Sengupta, A., Pangle, L. A., *et al* . (2017) "Advancing Understanding of Hydrological and Biogeochemical Interactions in Evolving Landscapes through Controlled Experimentation at the Landscape Evolution Observatory." *Terrestrial Ecosystems Research Infrastructure: Challenges and Opportunities.* Pg 83-118.

[14]Ortíz-Castro, R., Contreras-Cornejo, H., Macías-Rodríguez, L., and López-Bucio, J. (2009) "The role of microbial signals in plant growth and development." *Plant signaling & behavior.* 4.8. Pg 701-712.

Temporal Variability of Soil Seed Banks in Lodgepole Pine Forests

By John A.F. Wendt and Mark W. Paschke
Colorado State University

Abstract

Soil seed banking is a seed dispersal strategy whereby plants increase the chances that their offspring are exposed to suitable habitat. Following disturbance, the soil seed bank is a potential source of new propagules for site colonization. This study used a chronosequence of Rocky Mountain lodgepole pine (Pinus contorta var. latifolia) stands in the Colorado Northern Front Range to understand how soil seed banks change through time following stand-replacing fire. Seed abundance and richness were estimated using a greenhouse emergence method. A second order polynomial regression of time since fire explained 17% and 23% of the variation in soil seed bank abundance and richness, respectively. Soil seed bank abundance and richness were low in young stands, highest in the 36-year-old stand, and remained low in old stands (> 80 yr). Changes in soil seed bank composition are likely associated with several processes: fire that destroys aboveground vegetation and litter and induces understory development, canopy closure that excludes shade intolerant understory vegetation, and dispersal from surrounding plant communities. Localized disturbance may indirectly contribute to replenishment of the soil seed bank by permitting light to penetrate the forest canopy, encouraging understory growth.

Introduction

The colonization hypothesis of seed dispersal suggests that since habitats change, dispersal in space and time allows parents to produce offspring capable of exploiting uncompetitive environments as they open.[1] Successful plants will be capable of achieving adequate propagule dispersal to ensure colonization of suitable habitat where and when it occurs. Under the colonization hypothesis, seed dispersal is limited by spatial and temporal barriers. Soil seed banking is one strategy plants employ to increase the probability that their offspring are exposed to conditions suitable for establishment and growth.

The composition of a soil seed bank at a given time and location is a function of input through seed rain and outputs through germination or death. These fluxes, and consequently, the composition of the soil seed bank, are modulated by a host of environmental factors, many of which are associated with time since disturbance. Time-related effects are especially apparent in forested ecosystems where the progression of structural processes influence microhabitat conditions at every developmental stage.[2,3,4]

Canopy closure is a likely driver behind seed bank changes in forests; understory components decline as taller plants outcompete them for light. In a review of 108 articles Hopfensperger found that species in forest soil seed banks tend to be dissimilar from the established aboveground species while dissimilarity increases with time since disturbance (based on Sørenson's index of similarity).[5] Hopfensperger's findings imply that in older forests, the seeds residing belowground originate from a different place or time and that seed bank contributions from local aboveground vegetation are negligible.

Revegetation of a disturbed site is contingent upon the regrowth of residuals: organisms or propagules that survive a disturbance event.[6] Soil seed banks are an important source of propagules in the post-disturbance environment. First colonizers can have priority effects, thus subsequently influencing community structure and composition. In light of the aforementioned temporal variability in forest soil seed banks, it is important to consider the manner in which soil seed banks change through time. This issue is especially pertinent for fire-adapted communities in which regular disturbance is an inherent, formative process.

Rocky Mountain lodgepole pine (*Pinus contorta* var. *latifolia*) is a fast-growing, shade-intolerant conifer common in sub-alpine forests throughout the U.S. and Canadian Rocky Mountains. Lodgepole pine forest is a classic example of a fire-adapted plant community.[7,8,9,10] Lodgepole pine dominance is perpetuated through the recurrence of fire: adult trees are readily consumed by stand-replacing crown fires causing seeds to release from serotinous cones. These seeds yield the next generation of trees, often resulting in uniformly-aged stands. As stands age, they become structurally and demographically heterogeneous as they are exposed to secondary disturbance from blowdown, low-severity surface fires, and disease. The severity and extent of secondary disturbances determine post-disturbance regeneration and composition of tree species: high severity disturbances in young stands favors further lodgepole pine establishment while low severity disturbances in old stands favors other species such as subalpine fir (*Abies lasiocarpa*).[11] However, the effect of stand age on the composition of the soil seed bank in lodgepole pine forests is poorly documented despite its potential to influence future successional dynamics. In this study, we sought to determine if there is a relationship between stand age and soil seed bank characteristics in lodgepole pine forests by observing differences in soil seed bank species abundance (the count of individual plants from a site) and richness (the number of species represented for each site) across stands of varying ages.

Methods

Study Area and Design

A chronosequence was constructed of lodgepole pine stands (n=9) ranging in age from 2 to 360 years in Rocky Mountain National Park (RMNP), Colorado, USA (one site, BE, was located outside park boundaries) (Figure 1 & Table 1). Elevations of sampling locations ranged from 2500 to 3000 m (8400 to 9800 ft). The study area straddles the continental divide in the Northern Colorado Front Range. The region has a continental climate, and annual precipitation averages just over 500 mm (20 in).[11]

Sites were selected to represent a broad spectrum of developmental stages: from

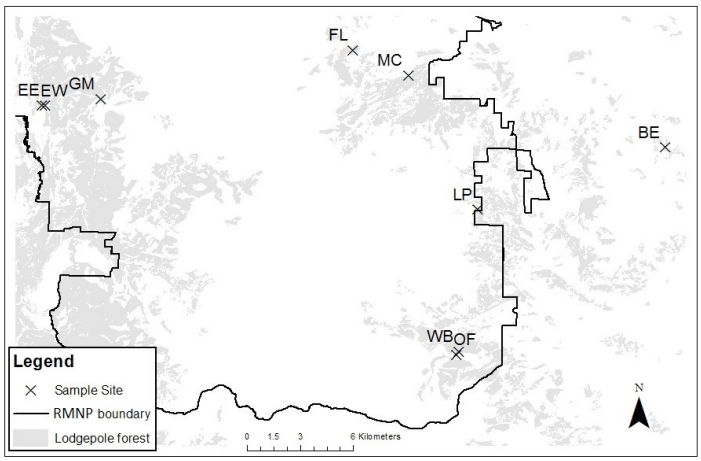

Figure 1: Map depicting the locations of soil seedbank sample sites (marked by "X") within Rocky Mountain National Park (RMNP), Colorado. Gray shading indicates extent of lodgepole pine forests.

Site Name	Age	Elevation (m)	Aspect	Easting	Northing
Fern Lake (FL)	2	2577	349° N	445446.7413	4466790.165
Big Elk (BE)	12	2685	51° NE	452497.2017	4457808.157
Ouzel Fire (OF)	36	2986	302° NW	451271.0952	4449635.541
Longs Peak (LP)	112	2910	75° E	452497.2017	4457808.157
Mill Creek (MC)	114	2566	2° N	448578.5348	4465370.372
Entrance West (EW)	143	2696	189° S	427909.8083	4463659.124
Entrance East (EE)	232	2684	121° SE	428089.8443	4463684.632
Green Mountain (GM)	232	2950	129° SE	431209.1684	4464043.097
Wild Basin (WB)	319	2967	332° NW	451420.8309	4449827.682

Table 1: Summary of sampling sites from lodgepole pine stands of varying ages in the Colorado Northern Front Range. Coordinates are Standard UTM, Zone 13N.

post-fire conditions (2 years) to the upper limits of the lodgepole pine lifespan and fire regime (360 years). Determination of stand age (time since fire) was based on historic fire occurrences documented by RMNP management and stand reconstructions from Sibold et al.[12] Sibold et al. identified fire rotations (the length of time necessary for an area to burn) ranging from 162 to 216 years in lodgepole pine forests in Rocky Mountain National Park.[13] Other studies have described similar fire regimes throughout the southern Rocky Mountains.[14,15,16,17] In recent years, lodgepole forests throughout the region experienced significant die-off from disease spread by the mountain pine beetle (*Dendroctonus ponderosae*). Old lodgepole pine stands (> 80 yr.) were most severely impacted.

Field Sampling

Field sampling took place in June 2014. Each sample site consisted of a 60- x 60-m area containing 16 gridded, uniformly spaced points. At each point, soil samples were extracted to a depth of 5 cm (from the surface of the mineral soil) with a bulb-planter. The point-samples from each stand were then pooled. If surface litter was present above the mineral soil, it was collected and stored separately. Soil and litter samples were placed on ice throughout transit and were then cold stratified in a refrigerator for approximately three months at 1° C prior to the germination phase.

Germination

Measures of the soil and litter seed banks were based on an emergence method. Following cold stratification, soil and litter samples were introduced to suitable growing conditions in a greenhouse at Colorado State University's Plant Growth Facility. Soil samples from each site were mixed and divided into two 400 mL portions. Each portion of soil was spread evenly over a sterile plant growth medium in well-drained flats (dimensions: 27.94- x 54.28- x 6.20-cm).

Different types of disturbances produce different post-disturbance conditions.[18] To account for alternative post-disturbance germination conditions and encourage more complete species representation, subsets of soil from each sample site were subjected to one of two treatments: "heat" and "litter". To simulate heat from a fire, near-boiling (94° C) water was poured over the heat-treated soil. Heat-treated soil was not covered with litter. The litter-treated soil was covered with 400 mL of litter (collected at sampling sites) and was not heat-treated to represent typical regrowth conditions following non-fire disturbance.

Throughout the 150-day growth phase from October 2014 to February 2015, the flats were maintained at 30.6° C on warming pads to stimulate germination. Flats were watered regularly (3-4 times weekly) and subjected to a 16-hour day/8-hour night photoperiod. Germinants were

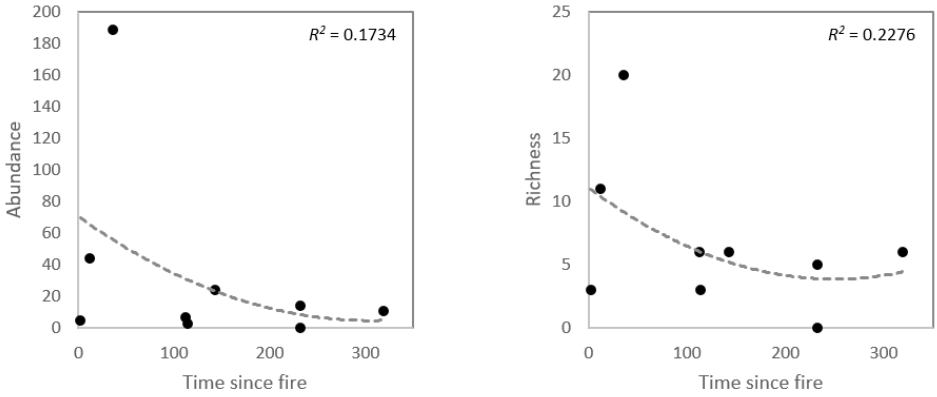

Figure 2: Scatterplots of time since fire versus species abundance and richness of lodgepole pine soil seed banks. Dotted lines are polynomial regressions fitted to the data.

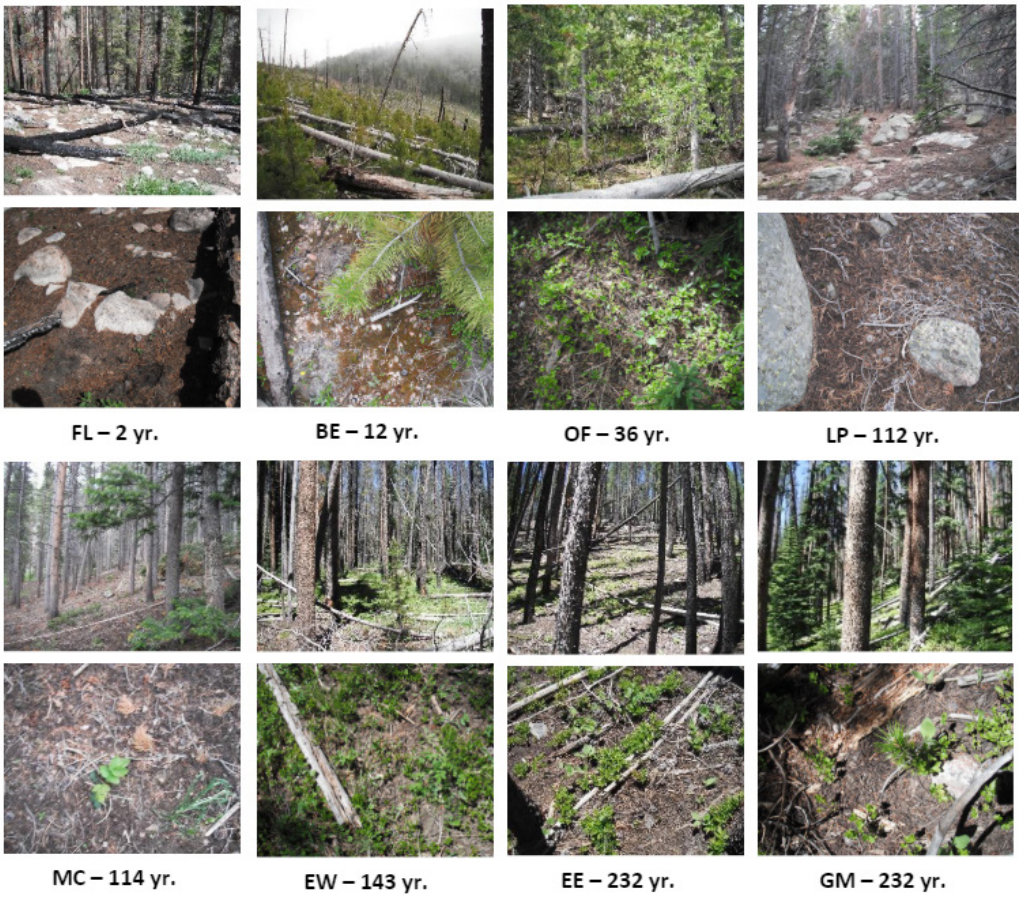

Figure 3: Photos of the understory (top) and forest floor (bottom) of eight lodgepole pine stands varying in age (2-232 yrs) in the Northern Colorado Front Range. Evidence of mortality from mountain pine beetle was observed in all old stands (> 80 yrs).

differentiated and identified with unique codes per species. Germinants were removed and counted after the growth phase. Germinant counts from "heat" and "litter" samples were pooled by site for analysis.

Statistical Analyses

Seedling emergence data were used to characterize each site's soil seed bank in terms of abundance and richness. Abundance is the count of individual plants from a site and richness is the number of species represented for each site. All statistical tests were conducted with Microsoft Excel (2013). A second order polynomial regression was performed to determine whether time since fire was associated with a curvilinear trend in abundance ($y = 0.0007x^2 - 0.4303x + 70.357$) or richness ($y = 0.0001x^2 - 0.0578x + 11.081$).

Results

Time since fire (age) did not significantly predict abundance ($R^2 = 0.1734$, $F(1,7) = 0.6235$) or richness ($R^2 = 0.2276$, $F(1,7) = 0.8348$) of germinants. Richness and abundance of seedbanks were both low in the youngest stands, highest in the 36-year-old stand, and remained at low levels throughout all older age classes (Figure 2). The polynomial regressions of abundance and richness begin high and gradually decline as time since fire increases. Evidence of recent disturbance was apparent at all sites. Young stands (< 80 yr.) were the products of stand-replacing fires. Older stands (> 80 yr.), where the legacy of fire was less obvious, experienced varying degrees of mortality due to beetle-kill. No lodgepole pine seedlings were observed.

Discussion

Although a small sample size limited statistical inference, the data portrays a pattern of changing soil seedbanks over time. Species abundance and richness in the soil seed bank of lodgepole pine forests appear to be influenced by at least three ecological processes: fire, canopy closure, and dispersal.

The rapid abundance and richness gains in the four decades following fire is likely a consequence of the accumulation of seeds from a burgeoning understory. As canopies in aging stands close over time, species richness and abundance in the soil seed bank appear to decline and then stabilize. These results concur with previous studies. Vose and White found that seed rain from grasses and forbs in ponderosa pine forests was 10-times greater beneath canopy gaps than below dense forest canopies.[19] Additionally, Abella and Springer observed larger soil seed banks associated with species-rich understories, sparse litter, and tree canopy openings.[20]

Following canopy closure, localized, secondary disturbances may contribute to the soil seed bank by freeing light resources to favor understory development. High seed abundance in the soil seed bank does not appear to be maintained throughout stand development, suggesting that seed longevity is generally short. Although the aboveground plant community was not quantitatively sampled, photographs of the sites suggest an association between understory development and the abundance and richness of the soil seed bank (Figure 3), with very little understory present in older closed-canopy stands.

Despite a century of fire suppression policy during the twentieth century, lodgepole pine forests in RMNP have not been excluded from the historic range of variability by altered fire regimes.[13] The oldest stand in this study (WB: 319 yr.) yielded abundance and richness values comparable to those of a stand over two centuries younger (LP: 112 yr.). Given the lack of complete soil seed bank demise with age it is reasonable to assume that substantial seed bank expiration occurs within the first hundred years of stand development for lodgepole pine forests. Thus, in the event of further stand-replacing disturbance, sites occupied by young stands may experience less understory seed limitation than sites occupied by older stands.

Conclusion

This study suggests that soil seed bank composition varies over time and is linked to stand development processes including disturbance, canopy closure, and seed rain from surrounding plant communities. The soil seed bank appears to increase initially after a disturbance and then to decline but not expire as stands age. Low-severity secondary disturbance may indirectly contribute to soil seed bank renewal by permitting light and encouraging understory development. Understanding the apparent linkages between the soil seed bank and aboveground conditions can help restoration practitioners and resource managers anticipate post-disturbance dynamics. Perhaps restoration treatment efficiency could be improved by targeted re-seeding of areas that are known to have fewer propagules residing in the soil seed bank. Future research should seek to identify and quantify the specific biotic and abiotic processes driving changes in soil seed bank composition and investigate the soil seed bank's role in shaping future communities.

References

[1]Howe, H. and Smallwood, J. (1986) "Ecology of Seed Dispersal." Annual Review of Ecology and Systematics. 13. Pg 201-228.

[2]Franklin, J., Spies, T., Van Pelt, R., Carey, A., Thornburgh, D., Berg, D., Lindenmayer, D., Harmon, M., Keeton, W., Shaw, D., Bible, K., Chen, J. (2002) "Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example." Forest Ecology and Management. 155. Pg 399-423.

[3]Nowacki, G., and Abrams, M. (2008) "The Demise of Fire and "Mesophication" of Forests in the Eastern United States." BioScience. 58.2. Pg 123-138.

[4]Maher, E., Germino, M., and Hasselquist, N. (2005) "Interactive effects of tree and herb cover on survivorship, physiology, and microclimate of conifer seedlings at the alpine tree-line ecotone." Canadian Journal of Forest Research. 35.3. Pg 567-574.

[5]Hopfensperger, K. (2007) "A review of similarity between seed bank and standing vegetation across ecosystems." Oikos. 116.9. Pg 1438-1448.

[6]Turner, M., Baker, C., and Peet, R. (1998) "Factors Influencing Succession: Lessons from Large, Infrequent Natural Disturbances." Ecosystems. 1.6. Pg 511-523.

[7]Power, M., Whitlock, C., and Bartlein, P. (2011) "Postglacial fire, vegetation, and climate history across an elevational gradient in the Norther Rocky Mountains, USA and Canada." Quaternary Science Reviews. 30.19-20. Pg 2520-2533.

[8]Brown, J. (1975) "Fire Cycles and Community Dynamics in Lodgepole Pine Forests." Management of lodgepole pine ecosystems: symposium proceedings. Pg 429-456.

[9]Mason, D. (1915) "The life history of lodgepole pine in the Rocky Mountains." U.S. Department of Agriculture. Washington, D.C.: USDA Forest Service.

[10]Clements, F. (1910) "The life history of lodgepole burn forests." U.S. Department of Agriculture. Washington, D.C.: USDA Forest Service.

[11]N.A. (2002) "Allenspark and Grand Lake monthly summaries for years 1944-1993." Colorado Climate Center. <http://ulysses.atmos.colostate.edu> (Accessed 03/01/2016)

[12]Sibold, J., Veblen, T., Chipko, K., Lawson, L., Mathis, E., and Scott, J. (2007) "Influences of secondary disturbances on lodgepole pine stand development in Rocky Mountain National Park." Ecological Applications. 17.16. Pg 1638-1655.

[13]Sibold, J., Veblen, T., and Gonzalez, M. (2006) "Spatial and temporal variation in historic fire regimes in subalpine forests across the Colorado Front Range in Rocky Mountain National Park, Colorado, USA." Journal of Biogeography. 33.4. Pg 631-647.

[14]Veblen, T., Hadley, K., Nel, E., Kitzberger, T., Reid, M., and Villalba, R. (1994) "Disturbance regime and disturbance interactions in a Rocky Mountain subalpine forest." Journal of Ecology. 82.1. Pg 125-135.

[15]Romme, W., and Knight, D. (1981) "Fire frequency and subalpine forest succession along a topographic gradient in Wyoming." Ecology. 62.2. Pg 319-326.

[16]Kipfmueller, K., and Baker, W. (2000) "A fire history of a subalpine forest in south-eastern Wyoming, USA." Journal of Biogeography. 27.1. Pg 71-85.

[17]Buechling, A., and Baker, W. (2004) "A fire history from tree rings in a high-elevation forest of Rocky Mountain National Park." Canadian Journal of Forest Research. 34.6. Pg 1259-1273.

[18]Swanson, M., Franklin, J., Beschta, R., Crisafulli, C., DellaSala, D., Hutto, R., Lindenmayer, D., and Swanson, F. (2011) "The forgotten stage of forest succession: early-successional ecosystems on forest sites." The Ecological Society of America. 9.2. Pg 117-125.

[19]Vose, J., and White, A. (1987) "Processes of understory seedling recruitment 1 year after prescribed fire in an Arizona ponderosa pine community." Canadian Journal of Botany. 65.11. Pg. 2280-2290.

[20]Abella, S., and Springer, J. (2008) "Estimating soil seed bank characteristics in ponderosa pine forests using vegetation and forest-floor data." USDA Forest Service. 35. Pg 1-7.

Assessment and Identification of Services for First Generation College Students

By Desiree Strange, Isabel Briseño, Alexis Gilbert, and Amanda Rivera

Tarleton State University

Abstract

First generation students are a population within higher education who exhibit their own unique set of needs. The purpose of this research was to identify the barriers in resources available to first generation college students. This mixed methodological study used both quantitative and qualitative questions from a modified survey of first generation students consisting of 38 questions. The sample size was 200 students attending a four-year university. A majority of the participants were 17 to 26 [94% (n= 189)] and White [69% (n=139)]. The researchers observed the financial difficulties of this population. The researchers found the majority of first generation students (69%; n=138) reported having financial difficulties. Research also found evidence of the need for increased awareness of resources, such as on campus programs; since 44% (n=89) of participants stated they did not receive any support. The implications focus on the population having increased access to resources on college campuses. First generation students need to have increased knowledge of what resources are offered on college campuses. To help first generation students become better prepared academically, emotionally, and psychologically, they should be offered services such as advising, mentoring and tutoring. Familial factors often negatively impact first generation students and their academic success. Offering support services could increase the retention rate and provide them with the help they may be too uncomfortable to request. The study findings allow heightened consideration of the first generation population by providing awareness of ways to access academic and financial resources.

Introduction

Obtaining a college degree provides advanced academic and economic opportunities within society. Sixty-five percent of jobs in the country will require higher education in the year 2020.[1] Currently about 90% of the US population holds a high school diploma, but only 33% have a college education.[2] Although this rate is steadily increasing, it becomes imperative for more of the population to be intentional about the pursuit of higher education. This intentional pursuit creates a new dynamic for higher educational institutions as they receive an influx of students who are first in their families to attend college. First generation students are defined as those whose parents never attended college or whose parents who have less than a high school education.[3] They make up a third of college enrollment nationally, with nearly half never completing with a degree.[4] More first generation students attend two year colleges compared to four year colleges and are more likely to be students of color, these students tend to be disproportionately Hispanic and African-American. Immigrant students are ten percent of the overall first generation population, with the Asian population (55%) and the Hispanic population (21%) having the largest numbers.[5]

The experiences of first generation students are different from students whose parents attended college.[3] Parents who did not attend college are potentially unprepared to transition the student(s), due to the absence of experiencing college themselves. This limited assistance places first generation students at a disadvantage compared to students whose parents have knowledge about navigating the higher educational system. Additionally, the family differences negatively affect the academic performance of first generation students through their entire college education.[6] These students experience a large gap from the first day of college entry compared to students whose parents attended college. Colleges can assist by providing services to positively influence students' success in obtaining a college degree.[3]

This study delves into the exploration of identifying additional barriers that impact the retention of first generation college students. The student researchers survey first generation students and gather data to assists colleges in identifying gaps students have experienced when trying to obtain services. Researchers utilized the term "gaps" as the point at which students are likely to have hardships in obtaining services on campus. The identification of gaps allows colleges to formulate a plan to provide services that can improve the college experience for first generation students.

Conceptual/Theoretical Frameworks

The current study utilized the Ecological Systems Theory as the conceptual basis for understanding and a resource to investigate relationships within social systems. The focus of the Ecological Systems Theory (EST) is the way in which a person interacts with their environment.[7] Using EST, researchers were able to understand how an individual can be affected within their system from the micro, mezzo, and macro levels. When observing an individual it was taken into consideration that they are in continual transaction with their environment.[8] EST highlights each aspect of how a particular person's life is composed of interrelated parts or subsystems constituting an ordered whole. Each subsystem impacts other sections of the whole system. For example, when a student is struggling in mathematics and does not find outside support, their grades start to decrease, and they are suspended from their collegiate

sports team in due to their poor grades. EST emphasizes how a person's environment can either negatively or positively affect a person's ability to attend college. When a student experiences financial difficulties such as the ability to pay for college or textbooks, they may require information and education pertaining to the available resources necessary to succeed.

Another theory the researchers used to assist in understanding the influences family has on a first generation student was the Family Systems Theory, developed by Murray Bowen in the 1950s. The Family Systems Theory (FST) is described as, "[a] theory of human behavior that views the family as an emotional unit and uses systems thinking to describe the complex interactions in the unit."[8] More specifically, family functioning is influenced by the family structure, such as boundaries, roles, expectations, and communication. Family functioning and family systems are shaped by individual functioning, which can create pathology within the individual.[9] FST emphasizes how a person's behavior and decision to attend college could be affected by the emotional aspects relating to their family and expectations. There is a possibility of students beginning to feel guilty or confused once they move away because they are no longer at home to take care of day-to-day responsibilities.

Both theories provided researchers with an enhanced lens on how to incorporate both the quantitative and qualitative methods. Researchers were able to purposively include additional demographic questions that assessed the availability of academic and financial resources for first generation students. Researchers also asked more specific questions related to the extent of family assistance, education, and knowledge prior and during the college experience.

Barriers for First Generation Students

First generation college students are primarily different than other students in that they do not enter into college with a familial forehand knowledge. Several studies discuss the barriers encountered by first generation students during their college experience. These barriers include family impact, family expectations, financial aid, and communication.

Family Impact

When students decide to attend college, family plays a primary role in their experiences and the impact families have on first generation students are not always positive.[10] Students have less than adequate skills when it comes to coping with stress and have a lower level of optimism. The family could inadvertently influence the student's success by not understanding the experience enough to guide them in a positive direction.

Students with parents who did not obtain a college degree experience two separate cultures: 1) the culture of their home, where parents may come from menial jobs such as manual labor and retail, and 2) the culture of college-educated individuals and their children. Students may experience stress as a response to the acculturation process they are experiencing between the two separate cultures.[10] In some circumstances, even when families have a desire to offer guidance during the acculturation process, parents without a college education cannot provide their children with the information necessary.[10] As a result, families display an insufficient amount of knowledge to help the child transition into the college atmosphere.[6] Alternative support can appear in the form of peer relationships once the first generation student starts classes. However, first generation students are also having to compete with these same peers who might display hesitation in providing academic support.

Family Expectations

While all college students may experience conflicts with family expectations, FGS have less than adequate skills when it comes to coping with stress and have a lower level of optimism.[10] The impact families have on FGS is not always positive. A student's culture and the way he or she was brought up influences the type of family expectations. Due to first generation students being the first to attend college or university, they struggle with managing feelings of guilt and confusion related to surpassing the educational attainment of family members and friends.[7] Parents who did not attend college may not set goals for their student, which could prevent students from achieving the maximum potential. The family could inadvertently influence the student's success simply by not having the experience to guide them in a positive direction.

Another hardship encountered, when focusing on family expectations, is the transition from high school to college. In some families and communities, interdependence offers a key role in influencing the first generation population. First generation students could experience a cultural mismatch when confronted with the norms of independence which are prevalent in college environments and might struggle with college curriculums, institutional policies, and teaching practices.[11]

In some of the situations occurring in the home of first generation students' parents, they often are more dependent on their student or vice versa; the student might rely heavily on the support of his or her parents. Students who come from parents who did not obtain a college degree may deal with two separate cultures: the culture of their home and the culture of college educated people and their children. According to Belanger, Boals, Connally, Duron, and Jenkins (2013), these students may experience stress reactions to the acculturation process they are experiencing going between the two separate cultures. In some instances, "even when families wish to be supportive, parents without a college education have less factual information to give and may be seen as less supportive by their children."[10]

Financial Aid

For students to begin considering higher education, they require the knowledge to know how they can gain access to the funds to pay for the cost of tuition and living. One of the many outlets to receiving funds is through financial aid. Financial aid is administered in multiple forms, such as grants, scholarships, and work study, which do not require repayment. However, loans which are considered self-help will start collecting interest after graduation and need to be paid back over time. Each financial aid option has a set of requirements, such as deadlines and paperwork. A student who is first generation and has never navigated through the process of financial aid may become overwhelmed and may require the support from experienced individuals. Stress can be alleviated by providing financial aid resources and support to first generation students who have never navigated through the process of financial aid. These students need assistance navigating the financial aid process as well as tools to assist them in completing documentation for grants, loans, scholarships, etc.[12] Financial aid navigation could come from high school teachers, counselors, social workers, advisors, or even college students and graduates who have been through the process of financial aid. By providing resources and counseling for those students who have little to no experience with financial aid, first generation students will could have a greater chance at succeeding in life after college because their finances and education are in order before entering the career field.

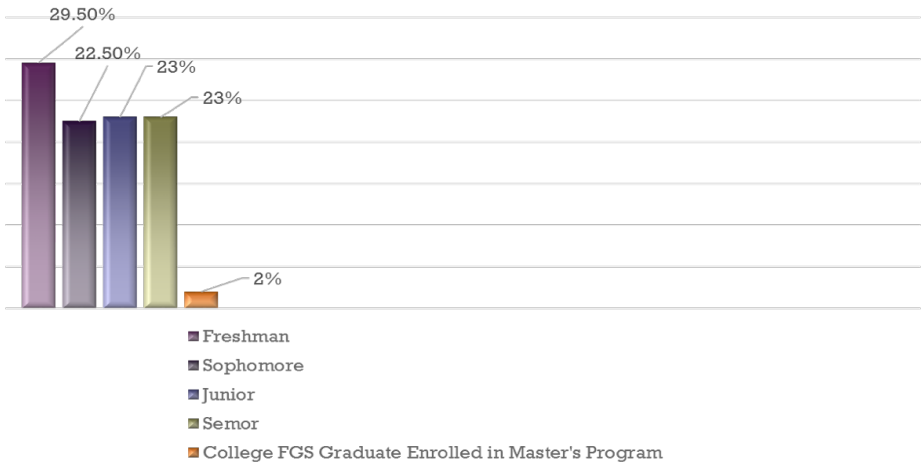

Figure 1: Student Education Level. This figure illustrates the educational level of the first generation students who participated in the survey.

Communication

Limited research is available about the first generation student population; the available research implies a gap in communication pertaining to first generation students on multiple levels.[13] Soria & Stebleton (2012) surveyed close to 2000 first year students to compare the degree of engagement and retention between first generation students and their counterparts. Findings show first generation students have a significant disadvantage in comparison to students whose parents have attended college. First generation students have a lower retention rate and limited academic engagement. Academic engagement derives from the ability to communicate one's needs. Many first generation students have limited social capital to develop adequate communication skills needed for building quality relationships at the college level. They are unable to rely on family or peer resources for navigating the academic institution such as seeking out faculty, which ultimately impacts the opportunity for mentorship.[11] Students are also less likely attempt to form these relationships due to low confidence and lack of preparation for a college level academic workload. They might not initiate themselves into school activities and "internal factors such as students' habits, attitudes, and interactions with teachers and other students may influence their success."[6]

Based on the past studies and integrating the bases of the Ecological Systems Theory and the Family Systems Theory, researchers sought to clarify and identify additional barriers for first generation students within a college institution. The main researcher objectives included 1) identifying which factors contributed to the student's decision to attend college; 2) determining the obstacles encountered during the application process; 3) observing the presence and prevalence of support; and 4) assessing the student's comfort level in communication with staff and peers during the process of receiving services or additional help.

The literature implications informed the hypotheses for this study. The first hypothesis was that a majority (51% or more) of first generation students will state financial difficulties as the greatest barrier to a successful college experience. Secondly, researchers hypothesized awareness of resources correlated with the first generation students' likelihood of accessing resources. Overall, this research examines pre identified obstacles to obtaining resources for first generation students including financial instability, communication issues, support from family members and support from faculty and staff on the university campus.

Methods

The purpose of surveying first generation students and gathering research data was to accurately identify the barriers first generation students have experienced when trying to obtain services. Researchers identified participants based on inclusion criteria of being enrolled at a four-year higher educational institution. All participants were retrieved from college institutions in the southwest region of the United States. The researchers compiled a 38 question survey to be administered to participants who identify themselves as a first generation college student. The survey consists of quantitative questions on a four-point Likert scale, such as pre-determined demographics of age, race, and ethnicity. It also consists of qualitative questions which asked what kinds of information would the participants find helpful online for first generation college students and if they had any family that has attended college and the highest degree that family member attained. Overall, the qualitative questions assessed the experiences of first generation students. All surveys were distributed to participants by the researchers, there were no electronic or mailed surveys involved in this study. Through the use of nonprobability sampling, researchers were able to identify the gaps in services and unavailability of services first generation students have experienced along their higher education journey.

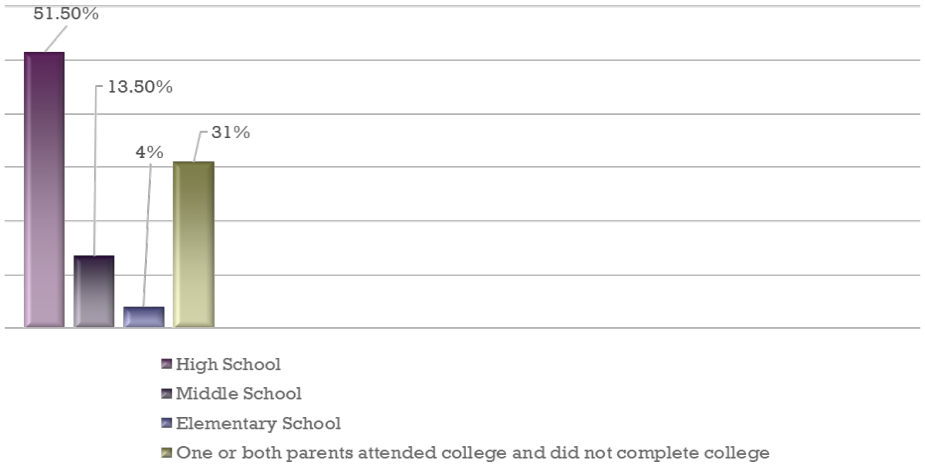

Figure 2: Parent Education Level. This figure illustrates the educational level of the parents of the first generation students who participated in the survey.

Participants

The researchers gathered responses from a sample size of 200 participants. Of those 200 responses, 94% (n=189) were ages 17 to 26. Three and a half percent, (n=7), of the participants were 27 to 36, 1% (n=3) were between the ages of 37 and 46 and less than 1% (n=1) of the participants surveyed were in the age range of 47 to 56. The racial makeup of the participants were White (69%; n=139), Black/African American (15%; n=30), American Indian/ Alaska Native (3%; n=6), Asian (2%; n=4), and Hawaiian Native and Pacific Islander (1%; n=2). Researchers also analyzed responses from participants who were bi-racial, meaning they identify with more than one race. The results were White/ Black/African American (1%; n=2), White/ American Indian/Alaska Native (Less than 1%; n=1), and 8% (n=16) of the participants surveyed did not select a race.

Parental and Student Education Level

Figure 1 shows the current college grade level of the first generation students surveyed consisted of 29% (n=59) college freshmen, 22% (n=45) college sophomores, 23% (n=46) college juniors, 23% (n=46) college seniors, and 2% (n=4) of the first generation student population were college graduates who were first generation students and are now enrolled in a master's program. The students were asked to identify his/her parent's highest level of education (see Figure 2). Over 50% of the participants, 51% (n=103), responded in the affirmative to his/her parent's highest level of education being high school. Also, 31% (n=62) of students responded in the affirmative to one or both of his/her parents having had attended college but did not complete a degree. Adding to those responses, 4% (n=8) of students responded in the affirmative to his/her parent having only attended elementary school and 13% (n=27) only attended middle school.

Economic Status (see Figure 3)

The economic status of those surveyed was determined based upon seven categories selected by participants. The categories included long term poverty, working class, lower-middle, middle class, upper middle, and the wealthy. Six percent (n=12) of students reported experiencing long-term poverty, 15% (n=31) were identified as working class, 22% (n=45) were lower-middle class, 39% (n=79) identified as middle class, 11% (n=23) upper-middle class, 1% (n=3) described themselves as wealthy, and 3% (n=7) were unsure of what category he/she identified.

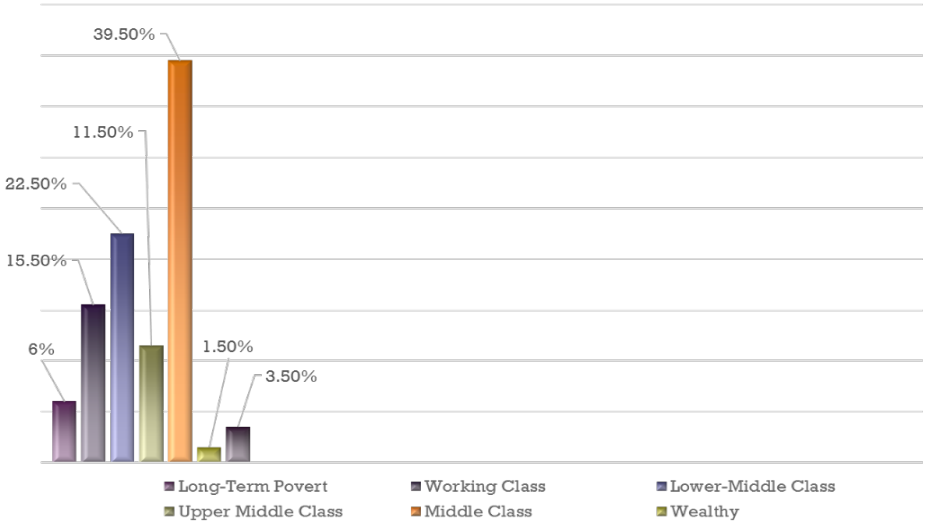

Figure 3: Economic Status. This figure illustrates the economic status level indicated by first generation students who participated in the survey.

Data Analysis

Based upon the hypotheses, the responses analyzed validated the hypotheses which stated:

> $H_{1:}$ A majority (51% or more) of first generation students on the TSU campus will state financial difficulties as the greatest barrier to a successful college experience.

One of the questions offered the participants the option to identify any significant barriers he/she faced during the application process. Of the 200 responses received, 69% (n=138) of the participants selected tuition/cost as the greatest barrier in their application process. The second most prevalent response was programs pertaining to social activities with informal parties which offered free food, attending on-campus events like plays, sporting events, performances and cultural attractions. The reasoning for this common response might be due to these activities being free of cost for the participants. The researchers analyzed the responses a question which asked the participants the type of support programs they would attend if offered at their school.

The most prevalent responses were programs pertaining to financial health and financial aid – information regarding managing student loan debt, managing finances generally, finding scholarships, and funding study abroad or other summer programs. Also prevalent from the first generation population was their response to programs pertaining to career development with information on how to find internships, networking events, resume and cover letter review, and career panels. Based on the results of the data collected, researchers were able to identify the financial aspect as a significant barrier for first generation students.

Researchers inquired if the university had provided any support for first generation students. Over 44% (n=89) stated they were not provided any type of support as first generation students; 28% (n=56) responded the university did provide him/her with support; and 27% (n=55) were uncertain if the university provided any support for first generation students. Due to the majority of students stating how they were not provided with any support as first generation students, the researchers view the low levels of support as a result of resources not being promoted effectively. Therefore, the second hypotheses related to awareness of resources was not able to be substantiated due to the lack of knowledge about resources or access to resources.

The researchers have identified barriers related to the finances serving as the greatest barrier for this population. Additionally, with the implementation of programs related to financial health, financial aid, social activities, and career development; first generation students will have increased knowledge of offered resources on the university campus.

Strengths and Limitations

With approximately half of the students on college campuses being first generation, the researchers were able to administer surveys with ease in heavily

populated areas across campus, such as the library and the student center. The willingness and cooperation of professors who allowed surveys to be distributed in classes assisted the researchers in capturing large groups of student participants and in distributing multiple surveys at one time. The researchers invested over a year's worth of time in studying this population and have completed literature reviews, policy analysis papers, and worked directly with this population.

Researchers also experienced and identified limitations of the research. Respondents to the survey became confused by use of the term first generation, because they assumed that first generation meant children of immigrants and not the first person in a family to obtain a degree. After identifying this constraint, researchers explained this limitation to respondents before they distributed the survey. The survey was six pages in length which may have contributed to participants not completing the survey. Participants did not answer every question on the survey or did not write "n/a" when necessary on the survey and those survey responses were unable to be utilized, or included in the data analysis. Another limitation is researchers only assessed the barriers of first generation students from one institution hindering the generalizability of the results. Also, the study was only conducted at one university setting due to time constraints and researcher availability to recruit. The researchers were on a limited time frame of two months to collect data.

Implications and Ethical Considerations

The study provides important implication for social work practice with the first generation population. The implications for social work at the micro level include identifying the cause of the hardships first generation students encounter and trying to eliminate those issues to increase the retention rate for future students in higher education. By identifying gaps, such as financial aid, leaving family, and working full time, professional social workers can identify the necessary resources to increase the retention rate of the first generation population. To help first generation students become prepared academically, emotionally, and psychologically, services such as advising, mentoring and tutoring could be beneficial. Giving first generation students these tools could counteract their struggles in family and work responsibilities, weak academic skills, inadequate study skills, and feelings of depression or stress which can negatively impact first generation students and their academic success.[13] Offering these services could increase the retention rate and provide first generation students with the assistance they are too uncomfortable to request.

Implications for social work on the mezzo level consist of the university implementing an orientation program or a webpage for first generation students. The website could include a question and answer tab to read about any questions or concerns that other students or alumni have experienced previously without the need to wait for emails or phone calls. The orientation could target the largest barrier identified. Implementing such programs would require further research and could prepare first generation students for college in an effective manner.

Finally, macro level implications would focus on advocating for policy at the state level to enact programs that are specifically tailored to benefit first generation students. In previous projects conducted by the researchers, no policies directly relating to first generation students were identified in the state of Texas. A potential policy implemented could be academic advising beginning at the high school level to prepare students for the requirements of college such as test score requirements, completing applications, and cost included in higher education. Implementing such policies would assist first generation students before they graduate high school. In regard to ethical considerations, professional social workers abide by a National Association of Social Work (NASW) code of ethics. The code of ethics provides the social work profession with a compass to guide the organization in enhancing the wellbeing of individuals and communities. In order for the social work profession to further assist the first generation population, it is important to maintain competence and enhance their expertise on their particular set of needs. According to the NASW, increasing professional knowledge and skills and applying them to practice is a goal social workers strive to achieve.[7] It is important for social workers to continuously learn and apply the knowledge obtained to practice in an effective way so they can provide the most effective service to clients.

As it relates to the ethics of the social work profession, workers' focus is to help individuals or populations who are underrepresented. Utilizing the knowledge, values, and skills and elevating service above self-interest is important in addressing social problems and assisting those in need when working in the field of social work.[14] When workers are assisting others it is necessary for the worker to provide service to individuals, groups, communities, and families by ensuring they are invested in providing beneficial resources for the client. By maintaining competence and serving, social workers are able to illustrate the importance of human relationships and the significance relationships have in the process of helping students continue their education, which are core values of social work. To strengthen relationships among people within the social work field, it is important for the worker to promote, maintain, restore, and enhance the well-being of individuals, social groups, families, communities, and organizations.[14]

References

[1]Carnevale, A., Smith, N. and Strohl, J. (2013) "Recovery: job growth and education requirements through 2020." Georgetown University Center for Education and the Workforce. Georgetown Public Policy Institute.

[2]Ryan, C. and Bauman, K. (2016). "Educational attainment in the United States: 2015 population characteristics." U.S. Department of Commerce. U.S. Census Bureau.

[3]Olson, J. (2014). "Opportunities, obstacles, and options: first-generation college graduates and social cognitive career theory." Journal of Career Development. 41.3. Pg 199-217.

[4]National Center for Education Statistics. (2014). Profile of undergraduate students: 2011-12. National Center for Education Statistics. U.S. Department of Education.

[5]Lederman, D. (2012). "Higher ed's other immigrants." Inside Higher Ed. Inside Higher Ed. <http://www.insidehighered.com/> (Accessed 11/02/2017)

[6]Wang, T. (2012). "Understanding the memorable messages first-generation college students receive from on-campus mentors." Communication Education. 61.4. Pg. 335-357.

[7]Bronfenbrenner, U. (1979). The Ecology of Human Development: Experiments in Nature and Design. Harvard. Pg 495-497.

[8]Hutchison, E. (2003). Dimensions of Human Behavior: Person and Environment. SAGE Publications. Pg 001-551.

[9]Robbins, S., Chatterjee, P., & Canda, E. (2006). Contemporary Human Behavior Theory: A Critical Perspective for Social Work. Allyn and Bacon. Pg 001-506.

[10]Jenkins, S., Belanger, A., Connally, M., Boals, A., & Duron, K. (2013). "First-generation undergraduate students' social support, depression, and life satisfaction." Journal of College Counseling. 16.2. Pg. 129-142.

[11]Garriott, P., Hudyma, A., Keene, C., & Santiago, D. (2015). "Social cognitive predictors of first- and non-first-generation college students' academic and life satisfaction." Journal of Counseling Psychology. 62.2. Pg 253-263.

[12]Harvey, T. (2014). "Cost and financial aid increasingly influence students' choice of college." Chronicle of Higher Education. The Chronicle of Higher Education. <http://chronicle.com/> (Accessed 03/28/16)

[13]Soria, K., & Stebleton, M. (2012). "First-generation students' academic engagement and retention." Teaching in Higher Education. 17.6. Pg. 673-685.

[14]National Association of Social Workers. (1999). "Code of Ethics of the National Association of Social Workers." NASW Press.

Do Mental Capacity Laws Unfairly Discriminate Against People with Disabilities?

By Matthew Grace
University of York

Abstract

This article shall argue that the UK Mental Capacity Act (MCA herein) is unfairly discriminatory towards mentally disabled people, although not irreparably so. Although this article inhabits the nexus between public policy and philosophy, my argument is primarily a philosophical exploration of whether the MCA adequately reflects and protects the autonomy of mentally disabled people. I shall therefore be examining the discriminatory effects of the MCA, as well as the nature of autonomy, in arguing that this legislation unfairly discriminates against people with mental disabilities. In section I I argue that: (i) The diagnostic component of the MCA is discriminatory and ought to be removed; and (ii) the functional test is indirectly discriminatory, while the unfairness of this discrimination is rooted in the application of the legislation rather than the legislation itself. I also observe that the flexibility of the MCA allows for societal prejudices to influence rulings, further disadvantaging mentally disabled people. In section II I contend that the individualistic model of autonomy the MCA is predicated upon fails to pay deference to the socially-embedded way in which each of us makes decisions, and that this inaccurate portrayal of autonomy – coupled with the unequal power dynamics that characterise capacity assessments – places an unfair burden on people with mental disabilities. I recognise that while there are people who cannot act autonomously, and best-interest decision-making may be necessary in such circumstances, the MCA does not achieve its aim of protecting the vulnerable in the least restrictive way, nor does it safeguard against the unfair discrimination of disabled people.

Introduction

Through the efforts of numerous campaigns, charities, and pressure groups, mental health has become a higher profile political issue in the UK, with each of the six largest parties (by votes) making commitments to mental health care in their 2015 manifestos. As political awareness and social understanding of mental health has developed, there is the risk that current legislation has lagged behind. In light of these developments, examination of the MCA is required to ensure that it furthers, rather than hinders, the progression of social attitudes and the safeguarding of liberty for those with mental disabilities. Within current legislation in England and Wales, legal capacity depends upon mental capacity – for one to be able to make a legally recognised decision one must have the mental capacity to do so. In the event that someone lacks capacity to make a decision with respect to e.g. their finances, living arrangements, health, or social contacts, a decision may be made in their 'best interests', even if the decision contravenes their wishes.[1] Best interest decision-making, however, reveals deep philosophical fissures. Respect for autonomy – broadly, the expression of one's will in accordance with one's values and principles[2] – serves as the value framework upon which discussion is built. Yet while it is generally recognised that mental capacity is required for autonomy[3], and that respecting autonomy does not entail allowing someone to suffer from decisions they lack the capacity to make, determining who lacks such capacity *in practice* is no simple task. Set the bar too high and we fail in our duty of care towards the vulnerable; set the bar too low and the liberty of autonomous people is curtailed.

At present the laws governing the (non-criminal) deprivation of liberty are covered by the Mental Health Act 1983 (MHA herein) and the Mental Capacity Act 2005. The relationship between these legal frameworks is a complex one, with each being applicable to the same individual,[4,5] however they serve slightly different functions. The MHA allows for patients diagnosed with a mental disorder to be detained and treated against their will, and is primarily concerned with the prevention of risk to either the patient or others.[6] The MCA, on the other hand, is concerned with specifying the legal conditions for mental incapacity and provides the general framework for best interest decision-making.[7] The diagnostic requirement of the MHA raised concerns in both academic and policy-making circles that the statute discriminates against those with mental disabilities[8,9] – a charge that has similarly been levelled at the MCA. However, while the prima facie discrimination of the MHA must be examined and addressed, this will not be the project of this article. My concern shall be restricted to the MCA as it constitutes the primary legislation under which mental capacity, and thus legal capacity, is evaluated. It is therefore the primary source of contention over whether existing mental capacity legislation unfairly discriminates against mentally disabled people.

Section I shall outline the key components of the MCA – namely, the functional test and the diagnostic threshold – and examine the extent to which they are discriminatory. I argue that: (i) the diagnostic component is unjustifiably discriminatory and ought to be removed from the MCA; and (ii) the functional test is unfairly discriminatory in practice, though not in principle. I also argue that the flexibility of the MCA allows for societal prejudices to influence rulings, disadvantaging mentally disabled people. Section II shall proceed to examine the individualistic conception of autonomy underpinning the MCA, and how this compares to more relational accounts. I contend that the individualistic model fails to pay deference to the socially-embedded way in which we make decisions, and that this inaccurate portrayal of autonomy – coupled with the unequal power dynamics that characterise capacity assessments – places an unfair burden on people with mental disabilities. I recognise that whilst there are people who genuinely cannot act autonomously, and best-interest decision-making may be necessary in such circumstances, the MCA currently does not

achieve its aim of protecting the vulnerable in the least restrictive way (s.1 (6)), nor does it adequately safeguard against the unfair discrimination of disabled people.

Section I

Denial of legal capacity on grounds of mental incapacity is decision-specific. For example, someone may lack capacity vis-à-vis their health whilst having capacity regarding their living arrangements. For a person to lack mental capacity under the MCA, two broad conditions must be satisfied. The functional component of the statute (s.3 (1)) stipulates that a 'person is unable to make a decision for himself if he is unable –

(a) to understand the information relevant to the decision,
(b) to retain that information,
(c) to use or weigh that information …
(d) to communicate his decision [by any means]'.[10]

If it can be established (on the balance of probabilities) that any of these conditions apply, then a person may be judged to lack capacity, if they also satisfy the diagnostic requirement. The diagnostic component states that a person lacks capacity if 'he is unable to make a decision for himself in relation to the matter *because of an impairment of, or a disturbance in the functioning of, the mind or brain*' [my emphasis].[11] Any ruling under the MCA must also accord with the principles of the act, as follows:

(s.1 (2)) A person must be presumed to have capacity,
(s.1 (3)) all practicable steps must have been taken before incapacity is declared,
(s.1 (4)) incapacity cannot be judged solely from an unwise decision,
(s.1 (5)) decisions made on behalf of one who lacks capacity must be made in their best interests,
(s.1 (6)) and care must be taken to ensure that the given purpose is achieved in the least restrictive way.

These principles, as well as the anti-discriminatory aims of the MCA (see s.2 (3)) and the MCA Code of Practice[12], shall be referred to in assessing the functional and diagnostic components.

The functional component of the MCA may disproportionately affect people with mental disabilities, but this alone cannot demonstrate unfair discrimination. By analogy, a police fitness test disproportionately disadvantages physically disabled people, but this indirect discrimination may be justifiable if the test requirements constitute a reasonable means to a legitimate end.[13] The reason we do not typically consider police fitness tests to be unfairly discriminatory is because fitness is a legitimate requirement for a front-line officer, and a fitness test is a reasonable means of assessing fitness. Similarly, if the functional test constitutes a reasonable means to a legitimate end then it will not be unfairly discriminatory. In principle, the functional test appears to satisfy this criterion. Understanding, retaining, using, and weighing relevant information, and being able to communicate a decision are all persuasive requirements for autonomy, while determining who has autonomy is a legitimate end. However, in practice capacity assessments are conducted in a way that isolates the assessed individual from their decisional support network – something that does not fairly reflect what autonomy consists of. Thus, although the requirements for capacity set out in the functional test are persuasive, the method by which they are assessed is predicated on an erroneous, overly individualistic conception of autonomy, leading to unfair discrimination. As I shall argue in section II, autonomy is not best captured through assessing an individual in isolation from their decisional support network. As people with mental disabilities tend to be more reliant upon such support networks, the consequence of this individualistic assessment practice is that autonomous people with mental disabilities will be subjected to paternalistic intervention more often than people with comparable autonomy who do not have a mental disability. Thus the way in which the functional component is applied constitutes an unreasonable means to a legitimate end: It is not the functional test *itself* that is unfairly discriminatory against people with mental disabilities, but rather the way in which it is operationalised.

The diagnostic threshold does not explicitly determine incapacity by reference to disability status, but rather an 'impairment or disturbance in the mind or brain', which is interpreted broadly and can apply to (for example) drunkenness.[14] From the outset, the diagnostic threshold will have discriminatory effects. This is because mentally disabled people will comprise a large part of the mental impairment category, and in cases where capacity is ambiguous under the functional assessment, people with mental disabilities will likely be found incapacitous far more than their non-disabled counterparts. The mental impairment clause means that only those who fail to demonstrate competency in communicating (via any means), understanding, retaining, or using and weighing relevant information – for reasons *other than a mental impairment* – would have their autonomy curtailed if the diagnostic threshold were jettisoned.[15] Notwithstanding the fact that someone who failed to meet such criteria would demonstrate a questionable degree of autonomy, why should they be regarded as deserving liberty when someone with similar decision-making powers, yet with a mental impairment, is deprived of theirs? It is hard to find a principled basis for why those who fail the functional test for non-cognitive reasons are more deserving of liberty, or less deserving of protection, than their mentally impaired counterparts. Moreover, since this discrimination stands in contrast to the anti-discriminatory aims of the legislation, the onus is on the diagnostic threshold to prove that it constitutes a plausible necessary condition for incapacity. We can contextualise this discussion by drawing upon an example that occurred prior to the MCA, where a patient with borderline personality disorder refused a blood transfusion on the grounds that her blood was evil, and that any transfused blood would also become evil. The judge stipulated that this belief was evidence of an inability to use and weigh relevant information, and therefore constituted evidence of incapacity[16], so we can assume the ruling would have been the same under the MCA. This contrasts with the general judicial acceptance of capacity regarding the refusal of blood transfusions on religious grounds. Let us suppose that there are relevant differences in capacity between these cases that ought to be captured in the legal framework. Arguably this could be achieved by s.3(1a) and s.3(1c), and if not – buttressing an insufficient capacity assessment with a discriminatory one of questionable relevance to autonomy is ad hoc and poor jurisprudential practice. Furthermore it shall be demonstrated that despite the principle of non-discrimination and the commitment to allow unwise autonomous decisions, the presence of disability does in fact influence judgements of incapacity.

Under the MCA, both the functional test and the diagnostic threshold are construed broadly. There are advantages to this flexibility – in some circumstances it may be difficult to account for incapacity in a rigorous way. This is especially true of people suffering from conditions that distort perceptions or values, such as anorexia nervosa or severe depression. People with such conditions appear to satisfy the functional criteria, but intuitively seem to lack capacity (for ego-syntonic conditions this intuition is even harder to underpin). The flexibility of the MCA allows for socially accepted, though under-substantiated, understandings of capacity to influence judgements, challenging the supposed

normative neutrality of mental capacity legislation.[17 18] In other words, such flexibility allows for social prejudices to percolate into judgements of capacity. For example, people with psychological conditions are far more likely to be deemed incapacitous than other groups '*in virtue of their* diagnosis'.[19] Similarly, Emmett et al. observed that for cognitively impaired patients 'professionals routinely made assessments that were outcome-driven rather than based on an assessment of mental function' – i.e. would base their assessment of capacity on whether the decision was rational or sensible.[20] While Williams et al. found that for some cognitively-impaired people 'a lack of capacity was assumed'.[21] These findings imply that, in practice, mental disability can colour judgements of incapacity – in direct contravention of s.1(2), s.1 (3), s.1(4), and the anti-discriminatory aims outlined in the Code of Practice. It is understandable that in circumstances where (in)capacity is not totally clear medical professionals prefer to err on the side of paternalistic caution, with the flexible criteria providing little guidance. However, superimposing one's preconceptions of mentally disabled people onto capacity judgements constitutes a discriminatory failure to ensure their liberty, suggesting the need for greater safeguards in capacity assessments.

Alternatively it may be the case that the diagnostic requirement helps to screen for incapacitous people[22], but this in no way justifies employing it as a *necessary* condition. Moreover, given that such screening is inherently discriminatory, the burden of proof is on the diagnostic threshold to demonstrate that such screening is so effective in identifying incapacity that this discrimination is justified (despite the anti-discriminatory aims). When we consider that mentally disabled people will be disproportionately impacted in cases of ambiguous capacity, and that the functional test's flexibility leaves scope for the prejudicial to influence the judicial, this burden may prove too heavy to bear. Of course, prejudicial attitudes could still influence capacity judgements were the diagnostic threshold jettisoned. However, removing the explicit link between mental impairment and incapacity would place greater emphasis on assessing capacity on an equal basis – if the functional test proves insufficient in this task, this would motivate greater rigour in the assessment criteria; if it proved sufficient, the association between cognitive impairment and incapacity, and the resultant stigmatisation of mental disabilities, would be further militated against with no ill effect.

Section II

The MCA is predicated upon a model of autonomy that venerates self-reliance and individualism. On this view, an autonomous person is someone who requires, and is subject to, little external influence or guidance in expressing their will. This is evidenced by the way in which capacity assessments are conducted – the individual is assessed with reference to their own decision-making capacities, severing them from the support networks that most of us make decisions within. Of course there is a point at which guidance becomes undue influence and undermines autonomy, and the courts have been attentive to this.[23] However this does not entail that any modicum of influence inhibits autonomy. Rather, 'appropriate social relations form an inherent part of what it means to be self-directed'.[24] Such relational accounts do not seek to reductively collapse individual capacities and needs into amorphous notions of relationality, but rather seek to recognise that employing narrow, atomistic accounts of autonomy 'can lead to a sterile and unsophisticated assessment … of capacity'.[25] Individualistic conceptions obfuscate the interdependent way in which capacity is formed, and in doing so unfairly disadvantages those with mental disabilities. The current way in which capacity is assessed isolates the individual from their support network, thus providing the assessor with only a partial representation of the individual's capacity – a partial representation that disproportionately harms those people who are more dependent on such networks, such as mentally disabled people. This is not to suggest that functional assessments are wholly inappropriate for determining capacity – indeed, self-determination depends upon internal competencies as well as external support. Rather it is to suggest that reliance upon others in certain domains should not be indicative of incapacity. Neither is this a castigation of best-interest decision making – this will be appropriate for those with severe impairments. However, it should be recognised that some people (such as the mentally disabled) require additional support to exercise the autonomy they *do* possess, and this admission should not impinge upon their right to liberty. Furthermore, when viewed through a relational autonomy lens it becomes clear that autonomy is better promoted through establishing support networks that enable people to fully participate in society, in turn facilitating the development of the competencies which autonomy (partially) consists in.[26] Identifying capacity through an overly individualistic framework (as the MCA does) can disrupt this process through unwarranted paternalism, fostering learned helplessness and arresting the development of autonomy in those whose support networks play a larger role in guiding decision-making. Therefore to better promote the autonomy of disabled people, the MCA should adopt a more relational approach to (in)capacity assessment, for example, through consideration of the support network available to the assessed individual, which would better reflect that which autonomy consists in whilst upholding liberty and protecting the vulnerable in a less restrictive, discriminatory way – consistent with s.1(6) and the Code of Practice.

Another dimension that unfairly disadvantages mentally disabled people is the unequal power relations that characterise capacity assessments.[27] This dynamic places the onus on mentally impaired people to demonstrate their capacity, a task which is likely to be more challenging for mentally disabled people who may be more reliant upon support networks for decision-making than others. Communicative failures are attributed to the assessed rather than the assessor. Indeed, 'case law offers several examples of people found to lack … capacity by assessors whom they did not like … only to be found to have capacity by other assessors'.[28] When this is taken in conjunction with the fact that disabled people are more likely to be subject to capacity assessments due to their diagnoses[29], the current approach places an unfair burden upon mentally disabled people and does so in a discriminatory fashion. All of this illustrates that in practice the flexibility of the legislation, the unequal power dynamics of the formal assessment process, and the stigma surrounding mental disabilities conspire to discriminate against disabled people. Moreover this discrimination has yet to be justified on autonomy-promoting grounds. It is important to note that this does not call for the wholesale abandonment of functionally determined best-interest decision-making, but rather calls for greater safeguards and more holistic assessment criteria in judging incapacity. If greater regard were given to the quality and stability of the individual's support network, if both professional and personal sources were consulted in determining capacity, and if capacity assessments were conducted in the presence of a key member of the individual's support network (perhaps alongside individual assessments), this would better reflect what autonomy consists in – providing assessors with a more comprehensive understanding of the individual's capacity while helping to reduce communication failures mistakenly attributed to incapacity. This will not entirely remove the difficulty in

determining who lacks capacity, and there will always be uncertain cases that generate concerns; however if these measures were implemented then mental capacity legislation would be better positioned to navigate this challenging ethical and legal area in a way that respects the autonomy of mentally disabled people.

Conclusion

The MCA in its existent form must do more to ensure the equal treatment of mentally disabled people. I have argued that the diagnostic threshold requires justification for its discriminatory practice to be deemed fair – a justification that has yet to be given. Meanwhile the functional test is unfairly discriminatory towards mentally disabled people, though not irreparably so. If the functional component can incorporate a more holistic assessment of autonomy that pays deference to the interdependent way in which capacity is formed, perhaps via some of the suggestions put forward above, then it will be able to ameliorate the unfair burden currently placed on mentally disabled people. I have acknowledged the difficulty of balancing flexibility and rigour in reconciling respect for autonomy with protecting the vulnerable, and there is perhaps no silver bullet solution to this. However introducing the changes mentioned above would help align the MCA with what autonomy consists in while reducing the scope for prejudicial attitudes to influence capacity assessments. Of course these measures alone would not be sufficient to combat the prejudicial attitudes themselves, and must rather operate in conjunction with a greater emphasis on educating society about mental health. This would help to help challenge the prevailing stigma surrounding mental disabilities, and may assist in mitigating the influence that social prejudice plays in judgements of incapacity. Equality and autonomy are principal aims of the MCA, and rightly so. With political will and social awareness, these aims can be realised.

References

[1] Highline Medical Services Organization. (2005) "Mental Capacity Act." s.1(5), s.4. <http://www.legislation.gov.uk> (Accessed 10/04/2016)

[2] Richardson, G. (2012) "Mental Disabilities and the Law: From Substitute to Supported Decision-Making?" *Current Legal Problems*. 65.1. Pg 333-354.

[3] Owen, G., Freyenhagen, F., Richardson, G. and Hotopf, M. (2009) "Mental Capacity and Decisional Autonomy: An Interdisciplinary Challenge." *Inquiry*. 52.1. Pg 79-107.

[4] *Ibid.* Pg 80.

[5] Sorinmade, O., Ruck Keene, A. and Moylan, L. (2015) "Addressing the Conundrum: the MCA or the MHA?" *Clinical Risk*, 21.2-3. Pg 31-36.

[6] Highline Medical Services Organization. (2007) "Mental Health Act 1983." <http://www.legislation.gov.uk> (Accessed 10/04/2016)

[7] p.257, Owen, G., Szmukler, G., Richardson, G., David, A., Hayward, P., Rucker, J., Harding, D. and Hotopf, M. (2009) "Mental capacity and psychiatric in-patients: implications for the new mental health law in England and Wales." *The British Journal of Psychiatry*. 195.3. Pg. 257-263.

[8] Department of Health. (1999) "Review of the Mental Health Act 1983." <http://www.mentalhealthalliance.org.uk> (Accessed 10/04/2016)

[9] Szmukler, G. and Holloway, F. (1998) "Mental health legislation is now a harmful anachronism. Psychiatric Bulletin." 22.11. Pg 662-665.

[10] Highline Medical Services Organization. (2005) "Mental Capacity Act." S.3(1). <http://www.legislation.gov.uk> (Accessed 10/04/2016)

[11] s.2(1), Mental Capacity Act 2005 (c.9). London, HMSO. Available at: http://www.legislation.gov.uk/ukpga/2005/9/pdfs/ukpga_20050009_en.pdf [Last accessed 10/04/2016]

[12] s.4(7-8), Department for Constitutional Affairs (2007). *Mental Capacity Act 2005 Code of Practice*. London, TSO. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/497253/Mental-capacity-act-code-of-practice.pdf [Last accessed 10/04/2016]

[13] p.16, Martin, W. Michalowski, S. Jütten, T. Burch, M. (2014). *Achieving CRPD Compliance: Is the Mental Capacity Act of England and Wales compatible with the UN Convention on the Rights of Persons with Disabilities? If not, what next?* Essex Autonomy Project Position Paper (University of Essex: Essex Autonomy Project, 2014) Available at: http://autonomy.essex.ac.uk/wp-content/uploads/2014/09/EAP-Position-Paper-FINAL-copy.pdf [Last accessed 10/04/2016]

[14] s.4(12), Department for Constitutional Affairs (2007). *Mental Capacity Act 2005 Code of Practice*. London, TSO. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/497253/Mental-capacity-act-code-of-practice.pdf [Last accessed 10/04/2016]

[15] p.36, Martin, W. Michalowski, S. Jütten, T. Burch, M. (2014). *Achieving CRPD Compliance: Is the Mental Capacity Act of England and Wales compatible with the UN Convention on the Rights of Persons with Disabilities? If not, what next?* Essex Autonomy Project Position Paper (University of Essex: Essex Autonomy Project, 2014) Available at: http://autonomy.essex.ac.uk/wp-content/uploads/2014/09/EAP-Position-Paper-FINAL-copy.pdf [Last accessed 10/04/2016]

[16] ss.61-63, The NHS Trust v Ms T [2004] EWHC 1279 (Fam). Available at: http://www.bailii.org/ew/cases/EWHC/Fam/2004/1279.html [Last accessed 10/04/2016]

[17] Freyenhagen, F. and O'Shea, T. (2013). *Hidden substance: mental disorder as a challenge to normatively neutral accounts of autonomy.* International Journal of Law in Context, 9(01), pp.53-70.

[18] p.90, Richardson, G. (2013). *Mental capacity in the shadow of suicide: What can the law do?* International Journal of Law in Context, 9(01), pp.87-105.

[19] p.1039, Banner, N. (2012). *Unreasonable reasons: normative judgements in the assessment of mental capacity.* Journal of Evaluation in Clinical Practice, 18(5), pp.1038-1044.

[20] p.77, Emmett, C., Poole, M., Bond, J. and Hughes, J. (2013). *Homeward bound or bound for a home? Assessing the capacity of dementia patients to make decisions about hospital discharge: Comparing practice with legal standards.* International Journal of Law and Psychiatry, 36(1), pp.73-82.

[21] pp.51-52, Williams, V. Boyle, G. Jepson, M. Swift, P. Williamson, T. Heslop, P. (2012). *Making Best Interests Decisions: People and Processes*. London: Mental Health Foundation. Available at: http://insidetime.org/wp-content/uploads/resources/Healthcare/Making-Best-Interest-Dec_MHF_2012.pdf [Last accessed 10/04/2016]

[22] Raymont, V., Bingley, W., Buchanan, A., David, A., Hayward, P., Wessely, S. and Hotopf, M. (2004). *Prevalence of mental incapacity in medical inpatients and associated risk factors: cross-sectional study.* The Lancet, 364(9443), pp.1421-1427.

[23] Series, L. (2015) "Relationships, autonomy and legal capacity: mental capacity and support paradigms." *International Journal of Law and Psychiatry*. 40. Pg 80-91.

[24] Oshana, M. (2006) *Personal Autonomy in Society*. Ashgate Publishing. Pg 49.

[25] Clough, B. (2015). *Exploring the Potential of Relational Approaches to Mental Capacity Law*. M.A. PhD Thesis. Department of Humanities, The University of Manchester.

[26] Mackenzie, C. (2013) "The importance of relational autonomy and capabilities for an ethics of vulnerability." *In Vulnerability: New Essays in Ethics and Feminist Philosophy*. Mackenzie, C., Rogers, W. and Dodds, S., eds. Oxford University Press. Pg 33-59.

[27] Beaupert, F. and Steele, L. (2014) "Comments on Draft General Comment on Article 12 of the Convention – Equal Recognition before the Law." Submitted to: United Nations Committee on the Rights of Persons with Disabilities.

[28] Series, L. (2015) "Relationships, autonomy and legal capacity: mental capacity and support paradigms." *International Journal of Law and Psychiatry*. 40. Pg 80-91.

[29] Keeling, A. (2016) "Supported decision making: the rights of people with dementia." *Nursing Standard*. 30.30. Pg 38-44.

International Developments Grab of Forests in the Global South

By John Mark Shorack
San Diego State University

Abstract

The World Bank financed "Climate Resilient Participatory Afforestation and Reforestation Project" seeks to reforest and afforest several regions of Bangladesh. It claims that increasing forest cover will protect the country better from natural disasters. The project also aspires to help the local people find alternative sources of income that do not cause deforestation. This paper examines the history of deforestation in Bangladesh, which extends back to the colonial period, as well as the underlying goal of the project to create 'pristine' forests in Bangladesh and open it to the global carbon credit economy, which requires removing the locals from the forests. This paper demonstrates the roots of the World Bank's narrative and that the project is harmful to the local Bangladeshi by taking away their livelihoods and resources producing stratified effects.

Introduction

The World Bank (WB) is one of the largest global organizations providing "low-interest loans, zero to low-interest credits, and grants to developing countries."[1] On February 7, 2013, the World Bank approved project P127015, titled Climate Resilient Participatory Afforestation and Reforestation Project, from this point forward referred to as "WB Afforestation Project". The budget is an estimated 35 million US Dollars. Due to the large number of grants given by the World Bank, and their huge impact throughout the Global South it is necessary to research deeper into the purpose of their projects and their impact on the local communities and governments. To accomplish this, a political ecology framework will be used to study the aforementioned WB Afforestation Project and provide a counter narrative to that of the World Bank by exploring the political-economic and socio-ecological dynamics of this project in Bangladesh.

Political Ecology focuses on challenging the dominant social, political and economic explanations of environmental change and conflict by digging deeper into the root causes of the problem, and the specific local history. This paper critically examines dominant international development discourses on climate change adaptation in the Global South by developing three interrelated arguments. First, I argue that the underlying assumptions that inform the World Bank's project reveal pervasive tendencies to blame deforestation and environmental degradation on the forest use and practices of local rural communities, rather than to consider the historically evident causes of exploitation of natural resources. Second, I examine how the forest conservation project is primarily aimed at promoting alternative livelihoods on the premise of incorporating forest spaces within an expanding global market for carbon credits. Third, I bring attention to ways in which the World Bank's alternative livelihood strategies produces stratified effects, as rural communities lose control over resources and livelihoods.

Political Ecology of Forests

To begin, the premise of Political Ecology is that most environmental problems have deep political and historical roots that must be understood to accurately address them. In this regard, Liberation Ecologies (Peet & Watts 2004) used the Political Ecology perspective to examine the political struggles for power and control over landscapes and livelihoods.[2] Describing how land is in the middle of political struggles for power not only in the present, but also the past. Another clear example of this is Paul Robbins' study on forest management in India (2001) where he presents the different viewpoints between the locals and the foresters in terms of what constitutes a forest, and he shows that their definitions depend on their respective interests and relationship with the land.[3] To the locals, conflicts over the meaning of forests became struggles over resources and their livelihoods.[4] However, it was more of a business venture for the foresters, who just wished to do their job by expanding the forest without considering the type of forests they were creating or the harm it caused to the locals.[5] The two distinct understandings lead to constant struggles over the forests in India. The project in Bangladesh leads to a similar interplay between the locals and the World Bank reforestation project. Both groups have special interests in the forests and in the region, but for different reasons. Because of the importance of the political struggle and the various viewpoints, this paper will take a similar approach as Robbins to analyze the international development discourses on climate change and their influence on the Bangladeshi forests.

World Bank and International Development in the Global South

The World Bank, established in 1944, is one of the main actors in shaping and implementing development agendas for the Global South. Their research, projects and suggestions become the dominant discourses for understanding and addressing a region's economic situation. These discourses, however, many times do not have a deep historical analysis to understand the root causes of social and ecological problems the local communities are facing.[6] Instead they only seek immediate causes and short-term solutions. Tadese Kidane-Mariam presents this explicitly in his case study of the African continent, specifically Ethiopia, where international development projects overlooked the needs of local communities, and instead sought to benefit foreign national and corporate interests. Kidane-Mariam describes how this occurs in Africa in that,

> "Global development institutions such as the World Bank have consistently argued that Africa's developmental and environmental crises are due to poor macroeconomic policy frameworks . . . the low level of integration of African economies to

world market and rapid population growth." [7]

The World Bank blames the crisis on the mismanagement of the local government and people. Ethiopia, one of Kidane-Mariam's case studies, has gone through many different international development projects which, according to him, have led to "uncritical policy implementations."[8] These policies were influenced by short-term goals to bring capital and money into the country and not by long-term goals that could contribute to the country's ongoing improvement and sustainability.[9] In Ethiopia one of the main goals was to 'bring foreign capital' into the country; in Bangladesh the World Bank has a similar goal. It is not meant as a project to contribute to revitalizing local lifestyle practices. For this reason, it is important to analyze the underlying explanation presented from the development agencies. Recently, reforestation of deforested areas has become especially attractive to international development organizations, such as the World Bank, because of the possibility of producing and selling carbon credits. Since 2000, Bangladesh alone has had 336 reforestation projects approved by the World Bank.[10] This shows how prevalent international development is in South Asia now.

Case Study: The World Bank Afforestation Project in Bangladesh

Bangladesh is at the center of the article because it is a country where the World Bank has had increasing involvement, and has the ongoing climate change project "Climate Resilient Participatory Afforestation and Reforestation Project." As stated in its main information sheet, the project seeks to increase the forest cover along the coastal and hilly areas of Bangladesh to better prepare the country for natural disasters."[11] One of the main ways the project hopes to maintain forests is to "reduce [the locals'][12] dependence on forest resources" by providing alternative livelihood options. Furthermore, the World Bank press release stated, "the project will create jobs in social forestry."[13] Similarly, in Ethiopia, it assumes that the practices of local rural communities are the cause for deforestation, and by decreasing their use of the forests the issue will be solved. However this narrative fails to show the roots of the deforestation in Bangladesh, and how it is not practiced by the locals but by large companies seeking profit. The following historical analysis will present how locals for many years used the forests in a balanced manner and are not the cause of the deforestation.

The deforestation in Bangladesh began hand in hand with the colonization of its land by Great Britain. Rasul (2007) explains that "between 1871 and 1885, three-quarters of the Chittagong Hill Tracts land [costal area in Bangladesh] was declared government forest land" during British rule.[14] This meant that the locals in this coastal area lost all the rights to their land and any form of economic activity previously derived from them.[15] The colonial government, furthermore, used the forests to export wood; and even "invited Bengali traders to extract timber from forests;" the deforestation, especially intensified once wood was needed to build the new railroads.[16] To replenish the forests the British replaced native multi-purpose wood from these forests with non-native mono-cultural teak plantations. Teak trees are not native to the local ecology and are used mainly for exports.[17] In 1971, Bangladesh declared independence and the national government outlawed the extraction of timber. Nonetheless a culture of deforestation was already present, so much that by the 1990s, "'logging trucks could be observed leaving Rang Amati in the direction of Chittagong every ten minutes.'"[18] Extractive forest practices initiated by the colonial government, and then continued by the illegal loggers, shows how deeply rooted the problem of deforestation is in Bangladesh, and how it is not a recent problem caused by the locals. It began when the British colonial power appropriated the forests, dispossessed the local people and displaced them from the land. The Chittagong forest is one of the main areas where the current World Bank development project hopes to address what it views as a contemporary problem of rapid deforestation. The World Bank is falsely blaming local communities for what has been going on since the 1870s.

The WB Afforestation Project is also shifting the livelihood of the local Bangladesh away from the forests and into different, new forms of livelihoods; not because it is better for the people, but because it will remove them from the forests. On a local level, the project wants the people to begin "goat and poultry rearing, vegetable cultivation [and] small scale trade." On a community scale, the World Bank is "establishing cooperatives for improving marketing channels for local products, water facilities, community based eco-tourism, making energy efficient cooking stoves, and agricultural firms."[19] This is a very drastic switch from the livelihood the local people previously practiced and it forces them to join the market economy.

In the past as explained by Rasul, "prior to the nationalization of forests, tribal people used to manage and use forest resources based on mutually agreed rules and regulations."[20] This arrangement allowed them to manage the forests sustainably without foreign intervention, but its abolition led to the exploitation of the forests' resources. Furthermore, Sheikh Tawhidul Islam, a Geography professor from Jahangirnagar University in Bangladesh, explains how locals from the Madhapur forests, of which the Chittagong Hill Tracts are part of, lived by "collect[ing] small twigs, chips of bark, branches" to use in their day to day lives and they also used certain roots, and wild fruits in their daily diet as well as for medicinal purposes.[21] This way they used trees for many different uses and maximized its benefits. These two case studies show the locals high-level of dependence on the forests for their livelihoods, however, without exploiting the forests. They managed the resources wisely and did not cause deforestation. Based on their proximity and historical performance, the locals are the best stewards to manage the forests in Bangladesh.

The implementation of new alternative livelihood for the locals is motivated by more than deforestation; its main goal is to create a 'pristine' forest to incorporate into the global market economy of carbon trade. This underlying goal is evident in the monetary contribution the WB Afforestation Project gives to updating and revising Bangladesh's Forestry Master Plan. The new version will incorporate "new and emerging dimensions for forest management such as carbon financing."[22] This revision of the Master Plan will allow transnational corporations and organizations to begin trading and selling carbon credits by reforesting in Bangladesh. It will open Bangladesh's forests to the global market. The World Bank predicted in 2013 that at the present value of carbon, the total revenue value, for the government, could be of $325 million dollars for the Bangladeshi forests.[23] But, the forests must be without local populations living in them.

This approach to forest conservation is not new. Tanzania sought to make a forest ready to incorporate in the market as well. They forced an increase in the mangrove forest cover in many areas of the country.[24]However, it had many drastic effects on the local people, which the Tanzanian 'conservation' project did not address. The government prevented the locals from growing rice, which was the food source for the communities, and insisted that they grow trees in its place. Furthermore

this project took away the local's title to the land and placed it in the hands of the government.[25] The approach they took in Tanzania is similar to the one taken in Bangladesh by removing the locals and taking over the control of the forests. The effect of this approach is to destroy the livelihood of the locals.

The narrative presented by the World Bank that the locals cause the deforestation, although not accurate, fits into the larger goals of removing the locals from the forests and by ignoring the deep historical roots of the deforestation the World Bank creates this narrative. As the government and forestry department gain control of the forests, the people who previously used it for their livelihoods are removed. With their removal they have lost access to their previous lands and their livelihoods. As a result, local communities lost their sustainable way of life, creating social inequalities and disparities in access to the forests and the money 'produced' by the forests. The use and management of the forest is passed on to the government.

This situation matches the case study conducted by Robbins in India (2001) because the World Bank similarly to the foresters in his case study view the forest in a different light than the locals. Additionally there is a political and economic struggle between the two for control over the land, because they both have a desire to control it.

Conclusion

To conclude, it is important to emphasize the intersection of all three arguments in relation to the World Bank narrative. Considering deforestation is an old, historical problem in Bangladesh not caused by the locals the World Bank's narrative in developing the WB Afforestation Project does not align with the larger historical context of the Bangladeshi forests. Secondly, the World Bank's special interest in building a forest for the carbon credit market discredits their support for the locals 'alternative livelihoods' only as a strategy to remove them from the forestry lands and force them to join in a market economy livelihood where they are required to buy and sell goods.

The project in Bangladesh is a prime example of how international development mobilizes discourses of climate change and forest conservation to open new forests to the global carbon market, and capital accumulation more broadly. This WB Afforestation Project is a specific example, where they plan to displace the locals who lived and relied on the forests. It serves as a guide to be aware and cautious with the reasons for expensive international development. It is important, therefore, to continue to think critically of the projects that international organizations hope to establish in the Global South. This research and understanding, however, must not stop here, but continue onward to develop better ways to manage forests in ways that promote socially just and sustainable practices.

Refrences

[1] The World Bank, "What we do." The World Bank. The World Bank Group.<http://www.worldbank.org> (Accessed 10/13/2017)

[2] Peet, R. and Watts, M. (2004) Liberation ecologies. Taylor & Francis.

[3] Robbins, P. (2001) "Fixed categories in a portable landscape: the causes and consequences of land-cover categorization." Environment and Planning A.33.1. Pg. 161-179.

[4] Ibid.

[5] Ibid.

[6] Islam, S. (2007) "Deforestation in Bangladesh: language and power in action." Narrative Inquiry. Pg. 149.

[7] Kidane-Mariam, T. (2003) "Environmental and Habitat Management: The Case of Ethiopia and Ghana." Environmental Management. Pg. 314.

[8] Ibid., Pg. 319.

[9] Ibid., Pg. 319.

[10] The World Bank Group. "Projects & operations - Bangladesh." The World Bank. The World Bank Group. <http://www.worldbank.org> (Accessed 04/16/2016)

[11] Ferdausi, S. (2012) "Integrated safeguards data sheet." The World Bank. The World Bank Group.

[12] Ibid.

[13] The World Bank Group. (2013) "Project signing: $33.8 million for afforestation to protect communities in coastal and hilly areas from natural disasters." Press Release. The World Bank.

[14] Rasul, G. (2007) "Political ecology of the degradation of forest commons in the Chittagong Hill tracts of Bangladesh." Environmental Conservation.34.2. Pg. 156.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Ibid., Pg. 159.

[19] Arannayk Foundation. (2013) "Environmental Management Framework." Bangladesh Forest Department. Arannayk Foundation.

[20] Rasul, G. (2007) "Political ecology of the degradation of forest commons in the Chittagong Hill tracts of Bangladesh." Environmental Conservation.34.2. Pg. 156.

[21] Islam, S. (2007) "Deforestation in Bangladesh: language and power in action." Narrative Inquiry.17.1. Pg. 147-148.

[22] The World Bank Group. (2013) "Project appraisal document on a proposed grant . . . to the People's Republic of Bangladesh" Sustainable Development Department. The World Bank Group.

[23] Barua, S. and Haque, S. (2011) "Soil characteristics and carbon sequestration potentials of vegetation in degraded hills of Chittagong, Bangladesh." Land Degradation & Development.24.1. Pg. 63-71.

[24] Beymer-Farris, B., and Bassett, T. (2011) "The REDD Menace: resurgent protectionism in Tanzania's mangrove forests." Global Environmental Change.22.2. Pg. 332-341.

[25] Ibid., Pg. 336.

"Heigh Ho" to "Let it Go": The Evolution of Gender Performance in Disney Princess Films

By Hayley Kessler, BA, BS, Breanna Dennes, and Milton Wendland, PhD
University of South Florida

Introduction

Walt Disney Animation Studios is a division of the Walt Disney Company, founded in 1923. Since its establishment, this company has earned recognition as a powerhouse in the film industry, and has come to produce content iconic for consumers of all ages. One of the most profitable facets of Walt Disney Studios includes the "Princess Line" of films. This line now officially includes eleven princesses and has accrued billions in merchandise. Disney markets movies, products, and merchandise quite literally from the cradle — using mobiles, onesies, and plushies — to the grave, with funerals and headstones featuring Disney's most famous movie characters and quotes. Considering the prevalence of Disney princesses in popular culture, it is important to recognize the impact that these films have on their young viewers. Children are especially affected by the media surrounding them daily. Moreover, Disney princesses seem to be a major focus of younger girls.

Because of Disney's societal ubiquity, researchers like Halim et al. and Merrick explored aspects of the characters and the hypothetical impacts of these films on children.[1,2] One in particular, "Gender Role Portrayal and the Disney Princesses", was of great interest in this project. In their research, England, Descartes, and Collier-Meek provided an analysis as well as a coding schema for all of the Disney princess movies from Snow White and the Seven Dwarfs to The Princess and the Frog, the film most recently released film at the time of their publication.[3] When first approaching this topic with respect to England, Descartes, and Collier-Meek's study, an obvious gap was noted in the literature. Since its publication in 2011, three more Disney princess movies had been released. Consequently, this research serves to modernize the previously conducted study by compensating for the gap in literature. Additionally, this study expands upon previous research to account for antagonists in each of these films, a factor entirely original to this study. This expansion furthers the investigation of how gender roles affect character portrayals throughout these films.

This project focuses on Disney princesses, their male counterparts, and their films' villains as well as the gender roles that each of these characters portray by both expanding upon previously unconsidered literature and more comprehensively investigating literature previously studied. Researchers viewed, analyzed, and coded for the following nine Disney movies: Snow White and the Seven Dwarfs (1937), Cinderella (1950), Sleeping Beauty (1959), The Little Mermaid (1989), Aladdin (1992), Mulan (1998), The Princess and the Frog (2009), Tangled (2010), and Frozen (2013). These films were strategically selected to provide a synoptic, albeit not exhaustive, sample of the manner in which Disney character portrayals may have evolved over the course of a century. The main interest of this study was to consider the evolution of gender portrayal in Disney princess films with respect to the implications of these gendered portrayals on young viewers.

During playtime, little girls can be seen emulating their favorite princesses, be it Rapunzel's vivacious personality, Snow White's mellifluous voice, or Ariel's iconic throwing-herself-on-the-rock scene. In contrast, male counterparts in Disney movies are generally portrayed as hypermasculine, especially in considering male protagonists from the oldest films. Although admittedly on a smaller scale, young boys may be seen emulating Prince Phillip's bravery when fighting a dragon or Flynn Rider's Machiavellian-esque charm. If one were to ask today's adults, many would have similar memories of mimicking these behaviors. However commonplace, the notion of little girls wanting to be a princess is nonetheless associated with perpetuating harmful or retrogressive stereotypes, such as equating femininity with passivity and viewing romantic relationships in terms of needing to be saved.

Disney movies have encompassed the central dogma of children's entertainment throughout the last century; children have subsequently been emulating these princesses for generations. As such, recognizing whether these highly regarded characters still portray traditional gender roles will help in determining the perpetuation of an outdated narrative in modern times. Throughout the course of this project, the hope is to comprehensively represent literature not previously examined, while considering how both conflict resolution and the portrayal of villains' gender roles throughout these films may propagate outdated ideals regarding gender and gender expression.

Literature Review

I. Gender roles and the Social Learning Theory

Albert Bandura's Social Learning Theory states that human behavior is learned through observation, imitation, and modeling.[4] There is no innate necessity for rewards or punishments in order to reinforce these learned behaviors, although they could serve to improve the process of learning. Kretchmar also discusses how there are three different types of observational behavior: live, verbal instruction, and finally, symbolic media, the aspect most heavily focused on throughout this project.[5]

Cohen emphasizes the impact of this theory on young minds, and discusses how the stereotypes portrayed in these movies can contribute negatively towards a child's growing sense of self.[6] Cohen also discusses Disney villains' appearances and behaviors, which often deviate from acceptable gender stereotypical portrayals. Cohen ultimately asserts that this representation links nonconforming individuals as characters who are untrustworthy and mischievous.

Two different studies conducted by Halim, et al. considered children and the rigidity of their ideals regarding their own gender performance.[1] It also considered how these performances may affect the way children act and dress. Ultimately, these studies affirmed that the more rigid a child's understanding of his or her gender, the more likely he or she was to conform to stereotypical notions of gender including dress, pragmatics, and mannerisms while engaging with others.

Another 2009 study was conducted in a kindergarten classroom with young girls considered "avid fans" of the princess genre. The study analyzed previously unexplored factors like princess toys and merchandise, looking at their impact on gender identities and discourses attached to the films. The notion of productive consumption explains how girls enthusiastically took up familiar media narratives, encountered

social limitations in princess identities, improvised character actions, and revised story lines to produce counter-narratives of their own.[7] The more familiar a child was with the storyline of her favorite princess, the more likely the child was to engage in activities or behaviors that the child thought her favorite princess would do as well.

II. Disney princesses and gender portrayal

Another study looked at a variety of Disney movies, from the oldest to most recent films.[8] It analyzed how the Walt Disney Company attempts to attract a greater adult audience and reaches a range of issues in contemporary cultural studies. Such issues include the performance of gender, race, and class, as well as engendered narratives in science, technology, business, and family life. The authors ultimately assert that, "sanitization of violence, sexuality, and political struggle [are] concomitant with an erasure or repression of difference".

A photo essay entitled "Part of Your (Patriarchal) World" investigated screenshots from the classic The Little Mermaid and explored how gender performances portrayed in those shots reinforce negative feminine stereotypes. It also analyzed the villainess Ursula and how Ariel and Ursula might represent heteronormative and queer points of view respectively, as well as how those portrayals serve to alienate specific audiences.[9]

A different study delved into Pixar movies.[10] Instead of gendered performances, however, the study almost exclusively considered characters' animations. Coding included whether characters were drawn with breasts, eyelashes, or their physical build, as well as whether or not they were employed, amongst numerous factors. This study concludes that, "results displayed no significant differences between males and females for most items." However, the content analysis omits significant differences between gendered portrayal, including inaccurate proportions or representations in voice or mannerisms. Furthermore, any differences between men and women are mentioned but minimized. As such, this study fails to achieve any insightful analysis regarding the true presence of gendered differences in Pixar animated films or the implications of these variances.

Three of the four films considered in Hoerner's article have significance in relation to this project, including Cinderella, Snow White and the Seven Dwarfs, and Sleeping Beauty.[1] This study indicates the negative possible implications perpetuated by traditional gender stereotypes in each movie. Hoerner asserts that female characters in these films are, "domestic, nurturing, and likely to marry because they seem incomplete without a man. These women are presented as inferior beings to men, and her appearance is valued more than her intellect." (p. 213). Conversely, Hoerner argues that powerful women are feared rather than celebrated, and tend to be portrayed as malevolent, intense, and unlikable villains.

England, Descartes, and Collier-Meek analyzed eight Disney princess films, then defined for and coded various traditionally masculine or feminine characteristics like assertiveness, tending towards appearance, bravery, indifference, and fearfulness, amongst others. Research conducted by England, Descartes, and Collier-Meek undoubtedly serves as the most influential study from which this analysis and coding were established and expanded upon. Ultimately, England, Descartes, and Collier-Meek assert that while protagonists in Disney princess films portray characteristics expected of their assigned gender, these behaviors become increasingly more androgynous over time. Finally, the authors cited the cultivation theory and constructivist approach to support their proposal that watching gendered content will likely influence gender development in children.[3]

III. Women's liberation and the Disney princess revolution

Alter's article in Time magazine discusses seven different Disney princesses and hypothesizes the values that these princesses would stand for if they lived in modern times.[11] The article effectively brands each of the princesses as feminist icons, highlighting their values and inner strength. This idea of reading feminism into such films reached an apex upon the release of Frozen. Law considers the unprecedented success of the 2013 film Frozen and attributes its success to both its progressive portrayal of female characters as well as its modern approach to traditional fairytale storytelling. Through simultaneously adhering to and challenging conventional fairytale themes and gender roles, Law asserts that the role of heroine and princess need not be mutually exclusive. Through its messages of familial love, self-discovery, and acceptance of diversity, Law asserts that this movie institutes an innovative model for the modern fairytale.[12]

Merrick's editorial for a London-based newspaper discusses how Frozen's Elsa serves as a superhero-esque figure for little girls who have not yet been affected by societal norms, like the author's own four-year-old daughter. Merrick discusses how Elsa's concurrent status as a queen and a figure of empowerment allows for little girls to see women in a role of power at an early age, a previously unprecedented event.[2]

Whelan's article centers upon the 20th century princess narrative as utilized by the Walt Disney Corporation to encourage its audiences to accept their position as girls and women in American society.[13] Conventionally, women are represented as traditional and submissive. While this article makes a strong argument for the negative role that 20th century Disney princess films had on influencing a woman's ideation of her "proper" place in society, it omitted 21st century films and subsequently failed to mention any progressive shifts made throughout these films to more comprehensively represent gender roles portrayed by the modern ideal woman.

IV. Villainy and diversity in Disney princess films

Lacroix's study considers five different female protagonists who were women of color in Disney movies. Lacroix interrogates the gender and race-related themes offered in these films, as well as the ways in which these ideas and the notion of whiteness operate within a larger socio-historical framework.[14]

Li-Vollmer and LaPointe's work investigates how perceptions of gender non-normative appearances, gestures, behaviors, and dialogues, termed "queering", are used as an indicator of villainy in children's animated films. The study considers ten male villains in animated films, and looks specifically at how the villains' portrayal of gender directly correlates to their portrayal as deviant and undesirable. This study also discusses the role of heteronormativity throughout these films.[15]

Moffit and Harris's study asks black mothers to reflect on the 2009 film The Princess and the Frog, in which the main character, Tiana, is black. Four themes emerged from their discussions: (a) film as negation; (b) princess as unattainable; (c) beauty as internal; and (d) work as virtuous. Moffit suggests that black communities consciously interrogate the images used to represent them in media in an effort to empower themselves and counter the seemingly incessant, prevalent, and degrading screen images they encounter.[16]

Hypotheses

Through research, the decision was made to include three main hypotheses, each related to the films' princesses, male counterparts, and villains respectively as the three main focuses of this project. Another hypothesis was dedicated to the films' resolutions. When looking at the princesses, it was theorized that as time passed, the princesses would become better-rounded characters, showing more balance in the masculine and feminine roles they portray. However, it was still expected that the princesses' actions would remain

Table 1: Masculine Coding Definitions

Characteristic	Definition
Curious about princess	Prince shows concerned interest in princess: who she is, where she is from, etc.
Wants to explore	Long for adventure, investigation and search into unknown
Physically strong	Ability to overcome someone/something by use of hitting and moving
Assertive	Assertion and affirmation of a position or idea. This can include assertiveness with or without aggression.
Unemotional	Suppression or lack of emotion shown in response to pleasure or pain
Independent	Not dependent on authority figure or another. This can include doing something out of the ordinary for a culture or performing an action against others.
Athletic	Running, jumping, kicking – anything that requires athleticism
Engaging in Intellectual Activity	Reading or showing use of thought
Inspires Fear	Causing someone to respond with fear or nervousness. This can be done through intimidation and violence but does not have to be intentional.
Brave	Courageous, daring, putting self in the way of danger
Described as physically attractive (masculine)	Attractiveness focusing on handsomeness
Gives advice	Providing guidance, including being asked or not being asked for help
Leader	One who leads a group including giving orders and directions

more feminine than masculine. Similarly, it was theorized that the male counterparts' actions would begin more stereotypically masculine, becoming more balanced as time moved on, albeit ultimately remaining more stereotypically masculine than feminine. The villains would display gender characteristics that deviated from the expected behaviors of their assigned gender. In considering conflict resolution, it was anticipated that the earlier movies would have more violent endings, while more recent films would experience a shift towards themes of love and familial acceptance.

Methodology

Since its founding in 1923, the Walt Disney Company has produced more than fifty five full-length feature films and as of 2016, garnered a total net worth of over ninety two billion dollars.[17] Its predominance has spread throughout the globe and encompasses many forms of entertainment, including six theme parks, several movie production businesses, partnerships with some of the biggest corporations in the world, and merchandise including toys, books, technology, and cosmetics. Disney characters are so easily recognizable by most people that they are even used in classrooms. As such, it is clear that Disney's marketing reach is broad. Their movies, especially those in the "Princess Line", have defined femininity and masculinity for generations. Just as today's youth is influenced by these films' portrayals, Disney influenced individuals nearly a century ago. Snow White is puerile and naive, all while sporting perfect-looking makeup, long flirty lashes, and graceful mannerisms. Two other original princesses, Aurora and Cinderella, are demure dreamers, with graceful movements and mellifluous voices whose main charge is to assist with household chores. Through the perpetuation of these outdated ideals, it can be argued that Disney characters represent an obsolete countenance as the "ideal".

Nine films were considered in order to demonstrate a comprehensive progression of gender roles throughout the timeline of Disney princess movies: Snow White and the Seven Dwarfs, Cinderella, Sleeping Beauty, The Little Mermaid, Aladdin, Mulan, Tangled, The Princess and the Frog, and Frozen. Including films released from 1937-2013, this sample was thought to be diverse and thorough, representative of the entire population of Disney films. For the sake of time and in an effort to avoid repetition, both Beauty and the Beast and Pocahontas were excluded since these movies featured similarities to films that were already being studied. Additionally, Brave was not included in the coding. While Princess Merida serves as the main character in this film, the film does not incorporate a significant male counterpart, and also embodies a "man against self" theme of conflict. As such, the film could not be entirely coded for. At the time of coding, Moana, the newest princess movie, had not yet been released and was thereby excluded. While researching for this project, it was noticed that there was a significant lack of comprehensive research on antagonists across any animated Disney film, which was accounted for by including villains in this research. The coders watched each of these films at least once, repeating watching the films as needed to assure precision and accuracy in results.

For the sake of consistency, this study built upon the coded content analysis as defined in "Gender Role Portrayal and the Disney Princesses" by England, Descartes, and Collier-Meek.[3] The coding outlined thirteen specific masculine traits and sixteen specific feminine traits. These traits included a multitude of behaviors like submissiveness, helpfulness, bravery, and leadership ability, as well as physical characteristics like athleticism. The full lists of coding definitions are listed below in Tables 1 and 2. Another factor coded for in the 2011 study was the films' resolutions, which can be seen in Table 3 below.[3] Resolution is operationally defined using the initial goals identified at the beginning of the films, as well as the means by which these goals are accomplished. This coding was incorporated in studying the female and male protagonists for all of the princess movies from Snow White and the Seven Dwarfs to Frozen.

Procedure

For this study, two coders simultaneously conducted content analysis. Each coder considered and coded for the pre-established masculine and feminine characteristics while watching the nine films. As mentioned above, these criteria were taken from an earlier study.[3] The list of traits to consider for was discussed to ensure precision and objectivity in

Table 2: Feminine Coding Definitions

Characteristic	Definition
Tends to Physical Appearance	Making physical appearance look better by adjustments (hair changed, makeup applied, etc.)
Physically Weak	Not being able to perform something that requires strength
Submissive	Yielding to authority through humility and obedience
Shows Emotion	Showing positive and negative feelings (only coded for princes— unreasonable to code for princesses because their emotions are shown consistently throughout the films)
Affectionate	Showing love or warmth for a person or animal. Can be shown through physical or verbal communication
Nurturing	Caring, showing motherly interactions, lending help in a compassionate way
Sensitive	Being aware of the issues of other people/animals
Tentative	Cautious and careful in behavior
Helpful	Giving help or assistance to another person or animal
Troublesome	Causing trouble or turmoil
Fearful	Showing fear or apprehension
Ashamed	Shameful, feeling of guilt
Collapses Crying	Character throws body down (onto bed or floor) and cries; face is not visible
Described as Physically Attractive (feminine)	Attractiveness focusing on beauty
Asks for or Accepts Advice or Help	Asks for help or receives physical, emotional, or mental assistance
Victim	Subjected to torture, physical harm, or abuse

Table 3: Coding definition for the films' conflict resolution

Resolution	Definition
Romantic	Film finishes with a romantic relationship
Violence	Conflict resolution is found through violence towards villain or antagonist
Acceptance	Conflict resolution is found through familial love or acceptance of differences
Achievement of Life Goals	Life goals discussed earlier in films are achieved

results. For example, researchers coded for characters' actions or spoken feelings. By nature of the behavior, these acts leave little to no room for interpretation. Removing ambiguity throughout coding led to consistent and reliable results while minimizing human error. To further ensure reliability by establishing a consistent baseline and resolving any inconsistencies, the coders initially viewed two movies together, Mulan and The Princess and the Frog, before coding the other seven independently. These movies were chosen as they deviated in some manner from "traditional" Disney princess films. For instance, Mulan impersonates a male for a significant portion of the film, thus some level of incongruence was expected in coding. In The Princess and the Frog, both the princess and her male counterpart are frogs for majority of the film, and this factor was anticipated to alter results to some degree.

Coding

Coding definitions for these films included gendered characteristics as applied to the princesses, male counterparts, and villains. The masculine and feminine characteristic coding definitions were adapted from "Gender Role Portrayal and the Disney Princesses."[3] The authors of this study established the coding definitions for the films' resolutions based on content analysis. Although it may be argued that the following coding definitions act to reinforce the very masculine and feminine stereotypes being critiqued, it is necessary to establish what would be stereotypically expected of a masculine or feminine character in order to most accurately assess and critique those narratives. Above, Table 1 and Table 2 outline the operational definitions for masculine and feminine characteristics coders considered. Table 3 depicts the coding definitions for the films' possible resolutions.

Coders were given a print-out of these characteristics as well as a blank sheet of paper, and tallied characters' masculine or feminine actions in a column labeled for each princess, male counterpart, or villain respectively. Every time a gendered activity was observed, a tally mark was coded. At the film's conclusion, tally marks were totaled and the overall ratio of each character's feminine to masculine actions was determined. The ratios for the princesses, male counterparts, and villains are displayed below in Figures 1, 2, and 3 respectively. Table 4 illustrates the results for each film's conflict resolution. These results were determined through discussion at the film's conclusion.

Discussion

Considering the first hypothesis,

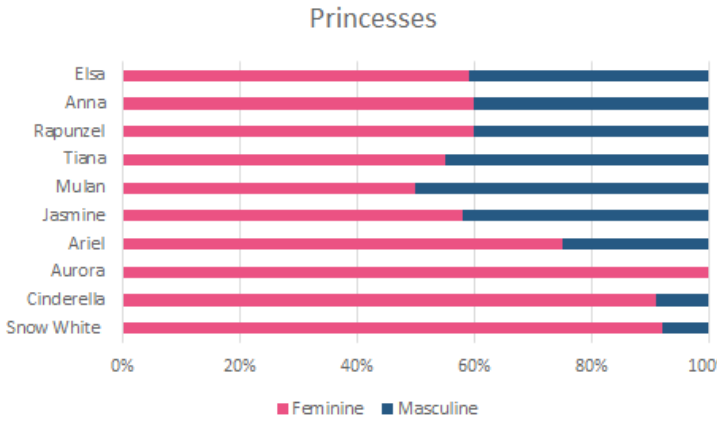

Figure 1: Percentages of each princess's ratio of feminine to masculine behavior

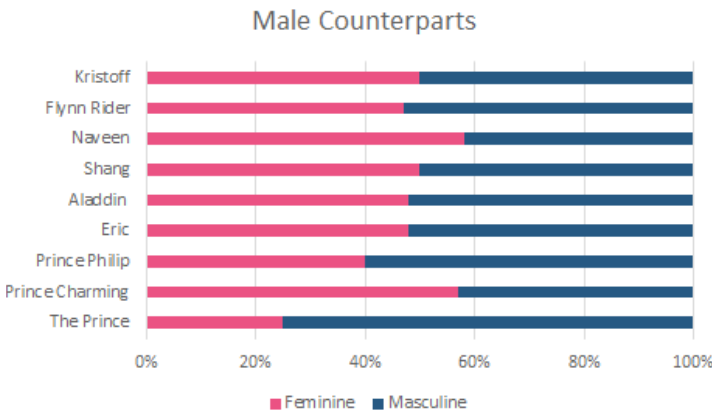

Figure 2: Percentages of each male counterpart's ratio of feminine to masculine behavior

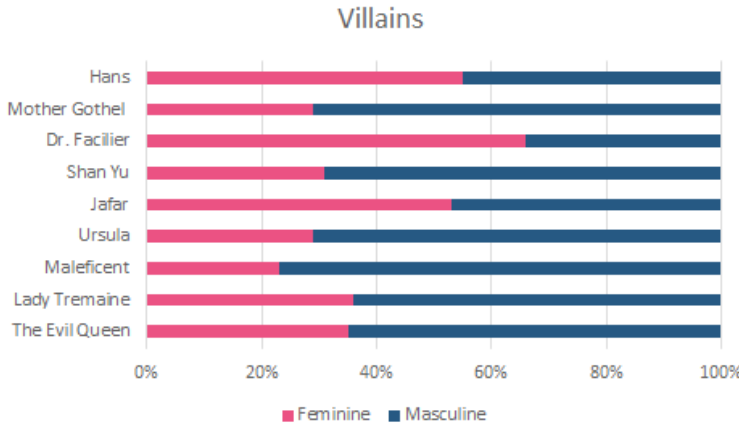

Figure 3: Percentages of each villian's ratio of feminine to masculine behavior

Table 4: Breaks down the means conflict resolution for each film

Film	Violence	Romantic	Familial Acceptance	Achievement of Life Goals
Snow White	X	X		
Cinderella		X		X
Sleeping Beauty	X	X	X	
The Little Mermaid	X	X		X
Aladdin	X	X	X	
Mulan	X	X	X	X
The Princess and the Frog	X	X		X
Tangled	X	X	X	X
Frozen		X	X	X

research indicated that the princesses progressively became more balanced between their displayed masculine and feminine characteristics. As such, outcomes supported the hypothesis. Starting with Snow White, coding shows in Figure 1 that her feminine characteristics outweigh her masculine characteristics by a large margin, with her feminine characteristics at 90% and her masculine characteristics at about 10%. These results are in accordance with Snow's identity as an affable and dewy-eyed adolescent who is easily frightened and avoids confrontation. Princess Aurora from Sleeping Beauty portrayed no observable masculine traits throughout the entirety of the film, although these results are likely skewed by the fact that Aurora received about ten total minutes of screen time and furthermore spent the vast majority of this time victimized in a variety of situations.

Considering Princesses Ariel and Jasmine from The Little Mermaid and Aladdin respectively, these women embody masculine traits more readily than their predecessors, such as Ariel's bravery and curiosity, or Jasmine's declaration that she was, "not a prize to be won." However, both princesses are still overwhelmingly feminine in the overall ratio of gendered behaviors that they display.

Mulan truly highlights the shift in portrayed masculine and feminine behaviors. Mulan is the only princess whose masculine and feminine behavior ratio was completely balanced, indicating that she portrayed an equal number of feminine and masculine actions throughout the film. This can likely be attributed to Mulan's ill-suited attempt in maintaining the perfect image of femininity for the first few minutes of the film, a stark contrast to her impersonation of a man throughout the next 40 minutes of the movie. A palpable contrast can be identified in Mulan's behaviors between these scenes. Mulan goes from wearing an ornate dress, primping her hair and face excessively, and partaking in the role of submissive housewife to chopping her hair off, speaking in a lower vocal range, and walking with a larger gait in an attempt to pass as a man. Immediately upon donning male characteristics, Mulan's interactions with other male characters change drastically, to the point where Mulan eventually outperforms her peers and is seen as a leader and model soldier. When it is ultimately revealed that Mulan is in fact a woman, her credibility and respect is immediately rescinded, and she is considered a pariah, despite having saved her unit from certain death at the hands of the Huns. Ultimately, Mulan finds balance in embracing her role as both a woman and a soldier until other characters accept Mulan's identity and in turn embrace their own femininity to save China.

Both Princesses Tiana and Rapunzel from The Princess and the Frog and Tangled respectively display feminine traits more frequently than masculine traits, though these behaviors are more balanced than the majority of their predecessors. These characters also have much more screen time than previous princesses, which allows for greater complexity and character growth throughout the films' progressions. This attention to detail may contribute to a greater balance in feminine and masculine behaviors portrayed, although it would not entirely explain this shift. Princesses Tiana and Rapunzel are independent, goal-driven, and serve as leaders in their respective movies. For instance, Rapunzel uses both wit and physical strength to knock unconscious a fully-grown man who intrudes in her home, and subsequently utilizes this leverage to strike a deal with said intruder to assist her in accomplishing her goal. Tiana, on the other hand, works tirelessly to achieve her dream of opening her own restaurant. She bravely leads her companions in a trek across the bayou and when her goals are questioned by her mother or male counterpart, Naveen, she fiercely asserts herself and reiterates her tenacity in working towards her goal.

The movie most recently released at the time of this project, Frozen, introduced two sisters, Princess Anna and Queen Elsa. As the most modern Disney princesses at the time of the coding, they served as the most contemporary example of complex feminine Disney princesses. As shown in Figure 1, both protagonists still coded as more feminine than masculine, mostly due to the fact that both princesses are victimized consistently throughout the film. For example, Anna is nearly frozen to death because of a man rejecting her love, and Elsa is imprisoned on charges of witchcraft because of her powers that she could not control. However, both Anna and Elsa displayed moments of tenacity and nerve that allude to the greater degree of balance in their masculine and feminine identified behaviors. For instance, after fleeing Arendelle, Elsa chose a life of independence and solitude, a behavior that is undeniably masculine. On the other hand, Anna set out on a solo journey to find her sister before she asserted herself to enlist the help of Kristoff, another unmistakably masculine trait.

In each film, the male counterparts overall exhibited more masculine traits than feminine traits, as predicted. However, the study found that when compared to their female counterparts, the princes displayed less predictability in their results. The princes tended to display higher levels of feminine behaviors than the princesses had masculine behaviors. This could be attributed to a number of factors, most plausibly the fact that it is more socially acceptable for a male to exhibit feminine behaviors (as in affection while wooing a woman) than it would be for a female to exhibit masculine traits.

Starting with the Prince from Snow White, it is obvious his coding is skewed to the masculine side, with his masculine score being around 75%. However, he had very little screen time, and in the bits of screen time he has he is either wooing Snow White or saving Snow White from certain death. Prince Charming in Cinderella deviated slightly from the score anticipated, with his traits skewed more towards the feminine side, at about 57%. Like Aurora, Prince Charming received very little screen time, and spent most of this time either waltzing with Cinderella or looking for her. Prince Philip, Aurora's counterpart from Sleeping Beauty, is a "man's man", and much of his gendered behavior comes from actions like saving the princess and fighting a dragon, but his scores were interestingly feminine as well. This feminine score could likely be attributed to his time spent wooing Aurora by singing and dancing with her.

Aladdin had the same score as Eric, from The Little Mermaid, and both were extremely close to being balanced, but ended up portraying more masculine traits in the end. Like his female counterpart Mulan, Shang is the first instance of a male counterpart showing complete balance in his gendered behaviors. Similarly to Mulan, Shang is thrust into a hyper-masculine role, and eventually had to surrender control and embrace his femininity to help save China via in the form of showing submission, even using Mulan's shawl trick to hide out at the top of columns. Naveen from The Princess and the Frog is the second male counterpart (following Prince Charming) to be display more feminine than masculine traits, and this is likely due to his fluid mannerisms and his victimization by Dr. Facilier, the villain who turns him into a frog. The second male counterpart who displayed perfectly equal scores for their masculine and feminine behaviors, Kristoff from Frozen, is Princess Anna's male counterpart. He began the film as a gruff and solitary ice salesman. However, Kristoff showed great compassion towards animals, primarily Sven, his reindeer sidekick. Additionally, he grew to care deeply for Anna by the film's completion. Both of these factions of Kristoff's countenance contributed to his character growth and ultimately impacted the ratio of his gendered behaviors, which caused his score to be completely even.

Every villain, save for Shan Yu in Mulan, was coded as displaying gendered behaviors that deviated from his or her

assigned gender, confirming the hypothesis that the villains' behaviors would diverge from the norms expected of them. The Evil Queen from Snow White, Lady Tremaine from Cinderella, and Maleficent from Sleeping Beauty all coded as more masculine than feminine, even with the limited screen time granted to the Evil Queen and Lady Tremaine. Maleficent was the most masculine of all the villains, likely contributed to by her heavy screen time. Maleficent's voice was very low and harsh, and her mannerisms radiated absolute authority and instilled fear upon every individual she encountered. She led an army of underlings whom she constantly berated. Maleficent serves as a highly interesting character as her fury originated from being snubbed at a party, but was expressed in a very masculine manner throughout the course of the film. The Little Mermaid's antagonist Ursula was large, physically strong, and independent, save for her leadership of two eel henchmen. She inspired fear in everyone she encountered, and her gruff voice and domineering countenance allowed her to assert control in situations she encountered.

Jafar, the male antagonist in Aladdin, was thin, angular, and nearly balletic in his mannerisms. He was conniving rather than aggressive, and repeatedly sought assistance from more masculine characters, like Aladdin and the Sultan, in achieving his ambitions. His melodious voice and consistent expression of emotion further serve to support his portrayal as an exceptionally feminine character.

Shan Yu continues the trend of the movie Mulan displaying unanticipated results. Shan Yu was the only male villain whose masculine traits were higher than feminine traits, these matching his assigned gender in a manner unexpected for that of a villain. He was incredibly aggressive and intimidating, tending to loom over other characters and lurk in the shadows. He held a very strong stance, with a purposeful gait, and he rarely spoke. Shan Yu likely displayed such strong masculine characteristics because his role in the film was solely to haunt and inspire fear into that of the viewer. Shan Yu had no character complexity and no redeemable qualities. In his own way, Shan Yu's hypermasculinity served a purpose to highlight the irredeemable nature of a man who is too masculine, just as it was unacceptable for any of the other male villains to display traits that were too feminine.

Much like Aladdin's Jafar, Dr. Facilier from The Princess and the Frog also coded as more feminine than masculine. From his emaciated and lithe frame to his elegant mannerisms and perfidious personality, Dr. Facilier drew attention towards himself in an undeniably feminine way. Facilier was also a voodoo practitioner, a craft often practiced by high priestesses. His need for power eventually victimized him, as he was sucked into a vortex by the very shadow creatures from which he drew his power. Interestingly, Dr. Facilier was feminine even in his acquisition of power, which he took or channeled from others (often more masculine characters like Prince Naveen), rather than creating for himself. In his final scene, Dr. Facilier was the epitome of frantic. Desperate and physically disintegrating, he begged shadow creatures for his life, another victimization and undeniably feminine action.

Mother Gothel from Tangled coded as more masculine as feminine. Her stance was very strong, her voice surprisingly sonorous, and she often took charge of situations in order to achieve her goals. For instance, she kidnapped Rapunzel as a child to maintain her youthful appearance, and later instilled fear in thieves to coerce them into assisting her recover the runaway Rapunzel. Mother Gothel was also very intellectually motivated, making plans and manipulating situations to benefit her and further her goals. Hans from Frozen was very close to being balanced between masculine and feminine traits, but ultimately coded as slightly more masculine than feminine. This is likely because he spent the majority of his movie acting as the perfect love interest for Anna — caring, warm, vulnerable, and not apt to take charge of situations, like when he only presided over Arendelle begrudgingly and at Anna's insistence when she was away. When Hans was eventually revealed to be the true villain, his demeanor immediately adopted a more masculine stance. He stood up taller, became more aloof, and his voice recognizably deepened as well. His intellectual manipulation was also revealed, which was coded for as a masculine behavior. However, since Hans was only known to be the villain for the last third of the movie, he was not awarded enough time for his masculine and feminine traits to become rebalanced. As such, he ultimately only coded as slightly more feminine than masculine in his behaviors.

Through the data collected, it was noted that almost all of the movies ended with some violent action towards the story's antagonist. For example, Mother Gothel (Rapunzel) falls a great height out of the tower and disintegrates to dust while Dr. Facilier (The Princess and the Frog) is dragged into a shadow realm by monsters. The conflict resolution of each movie did not shift exclusively from violence to love and familial acceptance as was expected, so this hypothesis was disproved. This result can most likely be attributed to the greater overall lesson towards young viewers: that villainous acts (i.e. deviating from the gendered norm) will ultimately lead towards the individual's unhappy ending. This lesson is prioritized over educating children about less violent means to resolve conflict.

The implications from this research are extensive. While the study supports other literature on this topic, this research also presented numerous trends that had not previously been explored. The masculine characters tended to express much more emotion than was originally expected, and this has great potential repercussions. The male counterparts from these films serve as strong role models for boys who grow up watching these films. These complex characters instill in young viewers that masculine characters displaying feminine attributes is nothing to be ashamed of or shy away from, especially in one's interactions with women. With respect to little girls exposed to these princess movies, the results tell a different story. While the more modern princesses are certainly more masculine in comparison to their predecessors, the princesses are still overwhelmingly feminine. These princesses reinforce dated feminine ideals, and as such, little girls who repeatedly watch these films might feel the need to portray more feminine characteristics in an effort to emulate the princesses they observe and idolize.

Additionally, the villains of these films almost nearly always tend to deviate from the behaviors expected of their assigned gender. This proposes a potential issue to children who view these films and even subconsciously interpret their own thoughts, mannerisms, or behaviors that diverge from their assigned gender as inherently "evil". The only exception to this finding is that of Shan Yu in Mulan, who portrays exceptionally masculine behaviors. In this case, it can be argued that by over-performing his gender, Shan Yu is also breaking gender norms. Like other villains who divert from traditional gender norms, Shan Yu meets a gruesome and violent end. This outcome suggests that male adolescents must find a balance between the gendered behaviors that they portray, as behaving in a manner that is either hyperfeminine or hypermasculine is not tolerated. Rather, in order to be accepted into society's standard, young boys' behaviors must be gendered, but not too gendered in either direction.

In addition to opposing gendered norms, the majority of villains from these films come to violent and untimely ends. These brutal demises teaches young children that they must conform to the standards set by society in order to lead successful and

happy lives. The Social Learning Theory suggests that a child exposed to movies or other media will have a tendency to imitate the roles and ideals they see portrayed.[4] This rings true for both genders, as both young boys and girls are shown what gendered behaviors are acceptable for them to adopt through the apparent successes or failures of the film's princesses, male counterparts, and villains.

These findings also impact the parents of children who watch these films. While newer films tend to conclude with familial reconciliation or a romantic relationship, the majority of the movies display a violent act necessary to defeat the antagonist. This could potentially lead to children becoming more aggressive, as they try to slay their own dragons or evil queens in solving their everyday problems. It could also lead to young girls becoming obsessed with doing anything to find their "one true love", a value reinforced time and time again in Disney princess movies. For those children who feel they do not fit into traditional gender roles, the negatively condoned behaviors and untimely ends of many of the villains may be seen as the consequence for acting out against the traditionally accepted behaviors for any assigned gender. Children may interpret these films as a cautionary tale, feeling a need to shy away from accepting themselves when their gender identity differs from that of their assigned gender.

Parents and educators alike should engage in candid discussions with young viewers about the portrayal of individuals of all genders in Disney princess films. The results of this study can be utilized to support this discussion, as children are challenged to assess not only masculine and feminine gendered expectations but also the repercussions of these expectations on their own lives and personal gender expressions. While Walt Disney Animation Studios has come a long way in its portrayal of princesses, princes, and villains in its films, there is still work to be done in order to most accurately depict complex and versatile characters, regardless of those characters' gender. In the meantime, individuals should work both to inspect the media they consume with a critical lens as well as to educate younger viewers in the manner that these films affect their own gender expression in hopes of raising a more tolerant generation.

Future Research Considerations

While this research has many notable implications, these results would be even more meaningful were they more comprehensive. This could be accomplished in a multitude of ways. Primarily, research should be expanded to include every princess, male counterpart, and villain from the Disney "Princess Line". Ideally, this would include sequels and live-action remakes as well. Sequels serve as a unique scenario as they allow for significant character growth over the course of multiple movies. As such, researchers may find meaningful changes in the gendered expression of the protagonists over time. In addition to expanding analyses to include the entire Disney Princess line, considering lesser-known Disney films may provide compelling results. Since Moana had not yet been released at the time of this project, it would be prudent for future researchers to consider this film as well.

Finally, future researchers also may want to consider the benefits of analyzing films from other production companies, including those of Paramount Pictures, DreamWorks, or 20th Century Fox. Specifically studying cartoon films like Anastasia, The Swan Princess, Thumbelina, or the Shrek franchise among others may provide experimenters with a broader perspective of gendered character portrayal in films on a more universal level.

References

[1]Halim, M., Ruble, D., Tamis-LeMonda, C., Zosuls, K., Lurye, L., and Hoerrner, K. (1996) "Gender roles in Disney films: analyzing behaviors from Snow White to Simba." Women's Studies In Communication. 19.2. Pg 213-228.

[2]Merrick, J. (2015) "Little girls dressing up like Elsa from 'Frozen' are the future of feminism." The Independent. <https://www.independent.co.uk> (accessed 02/23/2015).

[3]England, D., Descartes, L., and Collier-Meek, M. (2011) "Gender Role Portrayal and the Disney Princesses." Sex Roles. 64.7-8. Pg 555-567.

[4]Bandura, A (1977) "Social Learning Theory." International encyclopedia of psychiatry, psychology, psychoanalysis, and neurology. 10.1.

[5]Kretchmar, J. (2008) "Social learning theory." Research Starters Education: Social Learning Theory. Pg 1-6. Retrieved on February 23, 2015.

[6]Cohen, P. (2015) "The Trouble With Disney's Teeny, Tiny Princesses." Time magazine. 185.2.

[7]Wohlwend, K. (2009) "Damsels in discourse: girls consuming and producing identity texts through Disney princess play." Reading Research Quarterly. 44.1. Pg 57-83.

[8]Bell, E., Haas, L., and Sells, L. (1995) From Mouse to Mermaid : The Politics of Film, Gender, and Culture. Indiana University Press.

[9]Cho, M. (2014) "Part of your (patriarchal) world: gender performance in Disney's The Little Mermaid." Movable Type: An Undergraduate Media Studies Journal at the University of Virginia. Accessed 2/23/2015.

[10]Decker, J. (2010) The portrayal of gender in the feature-length films of Pixar Animation Studios: a content analysis. M.A. Thesis. Department of Science, Auburn University.

[11]Alter, C. (2015) "How 7 Disney Princesses Could Change the World." Time. Time Incorporated. < http://time.com> (accessed 02/23/2015).

[12]Law, M. (2014) "Sisters doin' it for themselves: Frozen and the evolution of the Disney heroine." Screen Education. 74. Pg 16-25.

[13]Whelan, B. (2012) "Power to the princess: Disney and the creation of the 20th century princess narrative." Interdisciplinary Humanities. 29.1. Pg 21-34.

[14]Lacroix, C. (2004) "Images of animated others: the orientalization of Disney's characters." Popular Communication: The International Journal of Media and Culture. 2.4. Pg 213-229.

[15]Li-Vollmer, M., LaPointe, M. (2009) "Gender transgression and villainy in animated film." Popular Communication. 1.2. Pg 89-109

[16]Moffit, K. and Harris, H. (2014) "Of negation, princesses, beauty, and work: black mothers reflect on Disney's The Princess and the Frog." Howard Journal of Communications 25.1. Pg 56-76.

[17][N.A.] (2016) "The Walt Disney company reports fourth quarter and full year earnings for fiscal 2016." The Walt Disney Company.