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Spring 2008

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Stanford Undergraduate Research Journal

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Editor's Note

This Spring 2008 issue of the Stanford Undergraduate Research Journal represents the seventh consecutive year of the publication of exemplary undergraduate research. SURJ's mission continues to be the emphasis and presentation of a wide array of research, covering the expansive breadth of work done by Stanford undergraduates, including the humanities, social sciences, natural sciences, and engineering. SURJ remains the only student-run organization focused on publishing the broad spectrum of undergraduate academic research.

SURJ continues its evolution, with this issue highlighting research grounded in the engineering fields. It is our hope that providing this new section will continue to expand the wide array of viewpoints and work that has long been prevalent at Stanford. We are also excited to be continuing a newer SURJ section by including nation-wide research for the second year. Our pilot program to promote a national section was a success last year, and we aim to continue this tradition in the publications to come. As in the 2007 issue, these papers can be found in the last feature section of the journal. We hope that the continued expansion of SURJ can underscore the work done at the collegiate level, and increase exposure to the contributions of this exemplary research nationally.

In respect to all of these changes, our fundamental commitment to quality on the editorial staff has continued to evolve, with the expansion of the student staff. The organization continues to grow with the publication.

As in the past, SURJ continues its relationship with the Undergraduate Admissions Office, which continues to send copies of the journal to high school students interested in research. SURJ staff has continued to play a significant role with its presence well-represented at the various symposia hosted by the Undergraduate Research Programs highlighting student research and public service. Our Special Features section continues to spotlight the diversity of work being done at Stanford, providing a fresh perspective on highly relevant and interesting research. It is our hope that these articles can provide a unique look at research and complement the research papers contained in this issue.

On behalf of the entire 2007-2008 SURJ Editorial and Production staff, we would like to thank you for reading our journal. It is the readership, new and old, that motivates the publication of this journal. Without the interest and boundless voices of support from the Stanford community, the journal could never be capable of reaching every undergraduate residence, library, and academic department on campus.

We hope that you enjoy reading about the research that follows this page, highlighting the work that continues a tradition of excellent research presented in SURJ, and will continue supporting and celebrating undergraduate research.

Sincerely,

Julian Hong and YunXiang Chu
Editors-In-Chief 2007-2008

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Special Features: An In-Depth Look at the Research Process

Research at Stanford provides great opportunities for students to become immersed in an individual course of study and conduct thorough research on a topic of their choice. Research projects can provide unlimited opportunities such as working in a lab, reading special collections, building prototypes, developing models, and collaborating with world-renowned faculty. Special Features is pleased to focus on the behind the scenes process that transforms a student's initial idea into a viable contribution to the academic community.

This year, we have chosen six students whose work spans the diverse fields of Human Computer Interaction, Psychology, Human Biology, Integrated Circuits, Nanotechnology, Plant Biology, and Antebellum American History. These projects not only represent new insights into expanding fields but often offer springboards for future work. For example, Michael Fischer's work on Multipoint Touch Sensors provides a prototype for a more natural way to interact with computers. Eileen Sisk's research provides a new approach to study Social Anxiety Disorders. Lucas Berla's Material Science study builds upon previously accepted models of integrated circuit failure and finds ways to accurately characterize hillock growth formation. Another Material Science student, Sam Rosenthal, has been working on organic solar cell technology. Emily Abrash's work on stomata development in plants tackles the problem of global warming from an unusual perspective. Alexis Smith's study of the Snuff Culture of Aristocratic Women in Antebellum America provides insights into a topic not frequently studied. We hope you enjoy reading about these students and recognize that their projects are the culmination of many hours of hard work, mentoring, experimentation, and enthusiasm.

Sincerely,
Michael Tamkin and Karis Tang-Quan
Special Features 2007-2008

Spotlight on Eileen Sisk: Changing the Ways We Think: New Research on Social Anxiety Disorder

Michael Tamkin[1]

Most people feel some anxiety when they walk into a party alone or meet someone new. While there are varying degrees of social anxiety, Eileen Sisk has chosen to study people who have such fears of social interactions that their everyday lives are severely limited. Currently a Senior Human Biology major working with the Psychology Department, Eileen thinks that she has discovered what may be a lifelong interest in the study of Social Anxiety Disorder (SAD). Since three to ten percent of the population will experience this disorder at some point in a lifetime, her interdisciplinary study will surely have a profound impact for later work.

Eileen knew that she wanted to do clinical research to study how cognitive therapy changes the way people think and whether this can be studied by changes in the brain. "I joined the Clinically Applied Affective Neuroscience program in the middle of my Junior year and continued to work through the summer and my Senior year," Eileen said. "We use fMRI, functional magnetic resonance imaging, to see how the brain is responding to social stimuli and how the responses can change. I joined the project at an exciting time, right when they began running the experiments."

"Because we run a research study on people with SAD, I interact with them a lot. Everyone has to be screened over the phone about their mental and physical health. For example, in doing these screenings I've learned that there are a lot of potential participants on thyroid medicine. The thyroid interacts with mood so we can't have those people participate in the study. Participants are mostly Bay Area community members as well as some graduate students."

Eileen's primary study involves looking at people's responses to clips of social situations. Her two groups consist of healthy people and people with SAD, comparing emotional responses of these groups to better understand the disorder.

The research process involves training participants to respond to the videos of social situations so that when they go in to the fMRI scanner, they can be cued to alter their thinking when viewing the social situation. "Being cued to think about situations differently causes better responses to negative stimuli," Eileen said. "Really we're going from black and white thinking, like '"Everyone thinks I'm stupid'" to a more gray context, like, '"They may think I'm stupid, but that is only one person's opinion, and they may be having a bad day.'" People list their thinking strategies and they almost always have added a personal twist to how we trained them."

Participants are involved with the study for over a year and a half, including four months of therapy, three months of initial follow-up, and a more complete follow-up for a year. Describing her study, Eileen says: "My data involves analyzing how people respond after they watch each video. They are asked to rate their anxiety level from 1 to 5. Simultaneously, fMRI scans are taken and will be analyzed at a later time."

While the research is ongoing, some findings are becoming apparent.

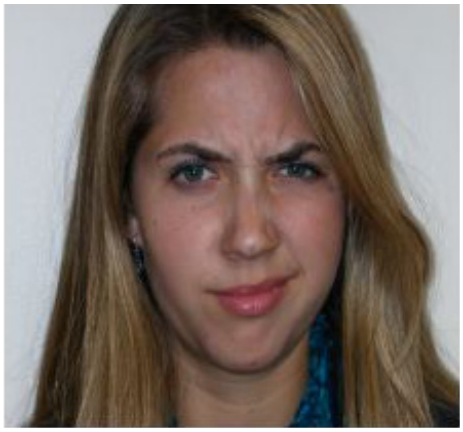

Figure 1: Research participants face social situations, like this actor saying to the participant, "You don't impress me."

Both healthy people and people with SAD experience reduced anxiety when they are cued to think differently when viewing the videos; however, people with SAD appear to have less of a decrease in negative emotion than healthy people. Eileen wonders if this difference is due to the fact that people with SAD have a higher anxiety level in the first place since cognition and emotion interact. Although it is known that cognitive therapy can help reduce social anxiety, Eileen hopes to better understand why cognitive therapy helps the patient and what part of the brain is being used.

Associate Professor of Psychology James Gross has been a tremendous influence in shaping Eileen's interest and methodology. "I took his emotion regulation class after I joined his lab. The class helped sculpt my research, and now he is my mentor for my research project. I learn so much in lab meetings because he really helps students break ideas down which is great in a murky subject like emotion where concepts overlap," Eileen said. She is hoping to publish the results of her project, which is currently part of an honors thesis in Human Biology. She has already presented her findings for Honors College and will also present her research to the lab.

As with all research, Eileen went through some dark moments

[1]Stanford University

wondering if her research would yield useful results. She was challenged by Professor Gross and her lab mates to "be more deliberate in my thinking and to think clearly when crafting my hypotheses." Although her research question has changed about four times throughout the process, she always knew that Social Anxiety Disorder was her main interest.

"When I got started, I wanted to do fMRI research because it is cutting edge and answering important questions," Eileen said. "However, there is also a lot of ambiguity at the moment since fMRI methodology can be contentious. Many people disagree about how to run these experiments, and what the findings mean. It was more important to me to do a research project and follow it through to get concrete results, and I learned to be patient and humble about what to study."

After graduation, Eileen plans to go to Alaska as a Jesuit volunteer and live in a community working for social and ecological justice. She will work with young people who have gotten into trouble with the law due to substance abuse. Her research with Social Anxiety Disorders has revealed that a higher percentage of alcoholism occurs among people with SAD than in the rest of the population. "In doing this project, I became very aware of substance abuse and how valuable it could be to learn about it and screen for it as a clinical psychologist," Eileen said. She is discovering ways to apply the research gathered during her SAD project and see how it could affect a larger community, such as young people with alcoholism. This kind of study reveals the benefit of interdisciplinary research, the connections between human biology and psychology, and the larger connections that can help many people in the future.

EILEEN SISK is a Stanford senior, soon to graduate with Honors in Human Biology. Her current research investigates cognitive regulation of emotion in Social Anxiety Disorder. After spending a year in Alaska with Jesuit Volunteer Corps, she hopes to continue pursuing research in clinical psychology graduate school.

Spotlight on Emily Abrash: Developmental Plant Biology Research affects Global Warming

Karis Tang-Quan[1]

While engineers are creating fuel cells with lower gas emissions and politicians debate the best way to limit air pollution, one young biologist is studying the systems that control stomatal production and distribution in plants to counter the effects of global warming. Most people do not think plant biology can have a great effect on environmental issues such as the rising carbon dioxide levels in the earth's atmosphere, but Emily Abrash believes her research can make a difference.

As a college freshman at Carleton College, Emily thought she was going to be a successful History or Classics major. She has the ability to communicate her ideas articulately and enjoys writing. However, one plant development class changed the direction of her college career. Emily was intrigued with the biology subjects and wanted to know more about the research process. When Emily transferred to Stanford as a sophomore, she actively searched for a biology laboratory. Her biology research career began in Dr. Dominique Bergmann's lab in the Department of Biological Sciences.

Dr. Bergmann, an assistant professor of Biology, leads a research group that uses *Arabidopsis* stomatal development as a model for understanding tissue patterning and cell fate. The lab is unique in its study of both the genetic and environmental factors on the binary cell fate decision. This Stanford lab focuses its attention on the molecular genetics underlying production, patterning, and morphogenesis of stomata and the epidermal cellular valves that regulate plant gas exchange. Due to its control over the plant's rate of photosynthesis and respiration, the stoma is a crucial part of the plant for scientists to understand. Stomatal development can influence global warming as well as give researchers more information on environmental fluctuations and biofuels.

Emily began her research by studying a mutation in *Arabidopsis thaliana* that was previously discovered by Dr. Bergmann who was a post-doctoral fellow at the time. The characterization of the *CHALLAH* family of proteins is important as they it appears to play a tissue-specific role in stomatal patterning. For the first year, Emily mapped the *CHALLAH* mutation, narrowing it down to a specific chromosomal region. With a candidate gene approach, Emily cloned and identified the gene. She found that the nature of the protein product was a small, potentially ligand-like molecule. This identification and characterization of the *CHALLAH* gene was just the beginning of Emily's research.

After isolating and cloning the *CHALLAH* gene mutation, Emily realized it had two putative homologues in the entire genome. She was then able to examine the phenotypes of double and triple *CHALLAH* family mutants. By knocking out the two homologues in experimentation, Emily is studying how the proteins interact with a particular family of plasma membrane receptors. These receptors are known to play a role in stomatal development of the plant. Emily looks for phenotype similarities between her knockout and crosses of knockout lines. Additional over-expression samples and GUS (β-glucuronidase) transcriptional reporters are used in experimentation to study the *CHALLAH* gene.

As mentioned before, Emily's research has a place in the greater picture of global warming. Though it is specific to the stomatal development and patterning in plants, her research provides insight to controlling a plant's ability to fix carbon dioxide and to prevent water loss. The molecular mechanisms that a plant carries out are important to the state of the environment. By understanding the systems of stomatal production and distribution, environmentalists will have a better approach to the tough issues such as global warming.

Figure 1: Large clusters of stomata on the hypocotyl (seedling stem) of a *CHALLAH* family triple mutant in a *too many mouths* background.

[1]Stanford University

Just as Emily believed she would pursue her interest in history or the Classics but changed her area of study, so as her research been a constantly evolving process. Emily began by simply trying to identify *CHALLAH*, yet she has made a significant contribution to understanding the interactions between plants and the environment. Emily attributes her wonderful lab experience to her great mentor Dr. Bergmann and supportive labmates.

Emily continues to use her communication skills as she pursues her scientific interests. At the American Society of Plant Biologists 2007 Summer Conference, Emily presented her research poster. Supported by the American Society of Plant Biologists SURF program, the Biological Sciences VPUE program, and a URP major grant, she hopes to publish her findings in a specialized developmental journal.

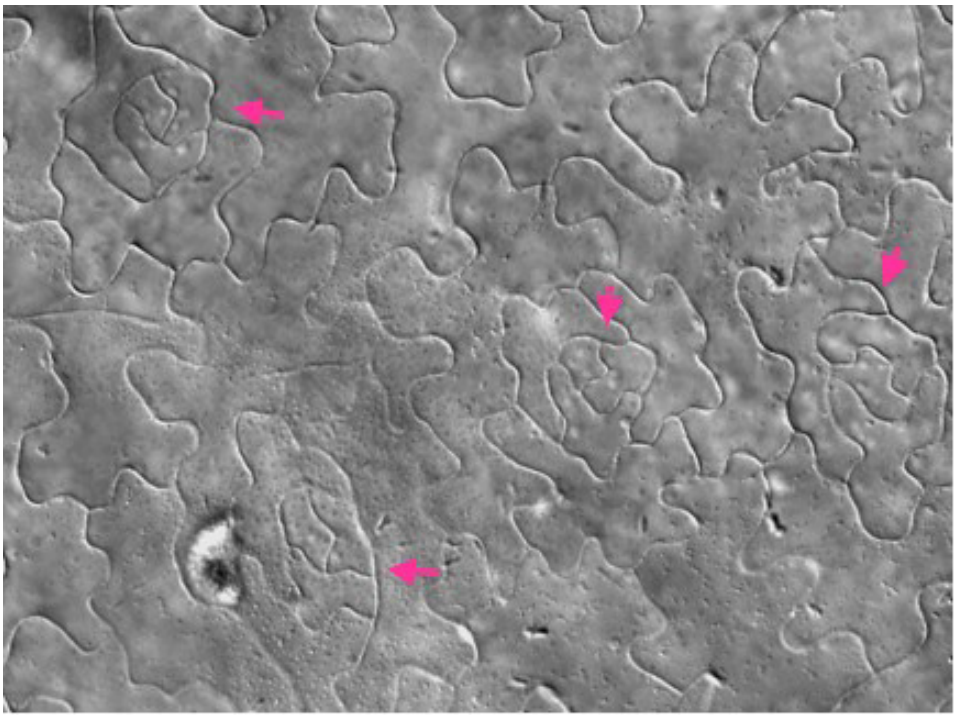

Figure 2: Leaf epidermis of a plant overexpressing *CHALLAH*. The arrows indicate stomatal lineage cells that have failed to differentiate as stomata.

EMILY ABRASH transferred to Stanford in the fall of 2005 as a sophomore. She will graduate this spring with a Biological Sciences major. After spending a year teaching abroad in Latin America, Emily plans to pursue a Ph.D. in developmental biology. At Stanford, Emily is actively involved with Science Bus, a group of undergraduate and graduate students who volunteer their time to run an after-school science program in East Palo Alto.

Spotlight on Michael Fischer: Multipoint Touch Sensors

Michael Tamkin[1]

As computers become more powerful, their integration into daily life continues to increase. People use computers to send e-mail, purchase items, find information, and perform myriad other tasks. One aspect that is often taken for granted is how humans send information to computers. The mouse and keyboard have been around for forty years and are still the primary means of human computer interaction. One student has been working on moving beyond this mechanism. Michael Fischer, a senior Computer Science major, has been researching a multipoint touch sensor that would allow people to communicate with a computer using touch, where the screen can respond to up to twenty different contact points at a time. This allows two users to use both of their hands to communicate with the computer. This technology is part of a growing movement that would revolutionize the way we use computers.

Michael began working on this project in Winter of 2006 with Computer Science Professor Terry Winograd, after taking Winograd's class CS 147: Human Computer Interaction. According to Michael, the primary motivation for his project is that "Humans have many different and complex ways to express themselves but computers only see us an entity with one point of contact, using the cursor, or the keyboard."

"I wanted to explore other modes of input to have a much richer interaction with the computer," Michael said. "As we move into mobile computing and as computers evolve into areas that go beyond the desktop, there are modes of input that can be more ideal than the mouse and keyboard. A lot of focus in computing is how humans can make the computer do something more advanced, but another important question is how we can get the computer to function closer to how we perceive information."

While much of Computer Science research involves programming and software development, Michael's project faced an extra challenge of developing hardware. "There was a hardware component to this, so there was a lot of ideation and

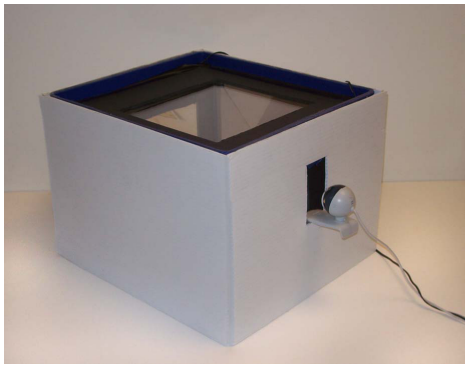

Figure 1: The input device built that can sense multiple points of touch simultaneously.

experimentation that went on to see how to come up with the final product," Michael said. "There were other ideas and models that we tried to use and probably 20 other prototypes that didn't work." Michael explains that one key element to his project is the use of a camera, because unlike a touch screen that can only process one point of information, a camera has "several thousand different pixels that can each function as an independent sensing device and measure data in different ways."

Michael developed his hardware prototype and software simultaneously, ultimately figuring out how to use plexiglass as a kind of fiber optic. "I experimented with shining light into the side of the plexiglass so that when you touch the plexiglass, it reflects light off of your fingers, and registers on the camera," Michael said. To process this information, he used a program called OpenCV, which can return an image captured by a camera as an array of pixels. This program contained a library that Michael could use to write a more complex program.

"Using the image processing program, there are operations that you can do on a frame of the movie to develop a raw image into a form that will work for sensory recognition," Michael explained. After that, he then had to write his own program that would enable the sensor to understand how multiple cursors are being used. "Once the computer sees the processed

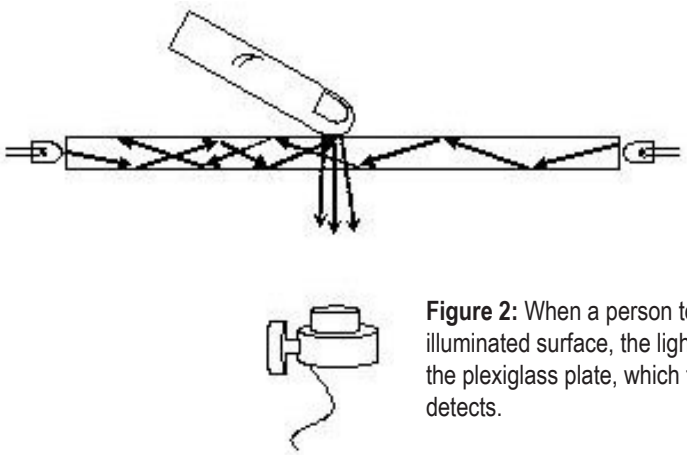

Figure 2: When a person touches the illuminated surface, the light leaves the plexiglass plate, which the camera detects.

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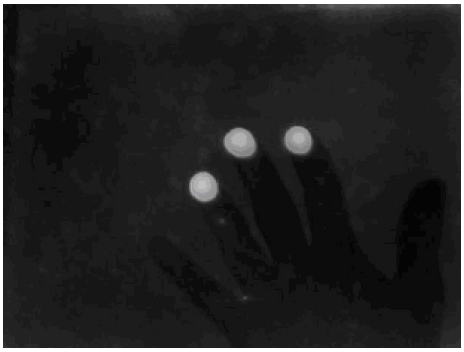

Figure 3: The image of the touch surface captured by the camera.

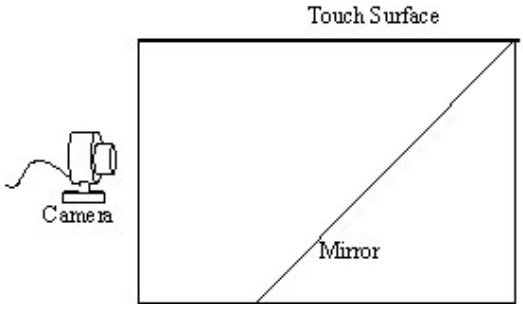

Figure 5: A mirror was added to increase the camera's range of view of the touch surface.

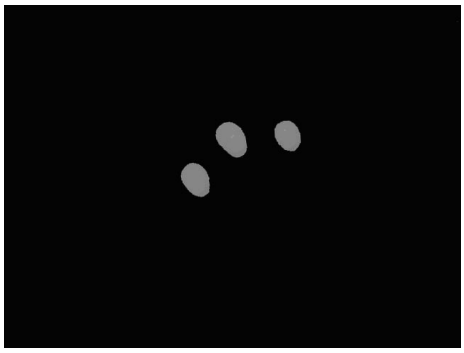

Figure 4: The final processed image.

image, it is able to extract contours out of the image, so that when you put three fingers down, it sends three events to the computer rather than just one," Michael said.

While research into touch is still a burgeoning field, Michael developed a sample program to show how his prototype unlocks new potential for working with computers. His test program involves displaying a photo and allowing the user to grab two points on the sensor and then resize and rotate it by moving their fingers. According to Michael, "this makes the process of resizing and rotating an image much more intuitive than with dragging a mouse. This is a way of bringing how humans normally would think about working with physical photos to the computer, and lets the computer work harder for us rather than us adapting to its model."

With the prototype that Michael has built, technology could be used to develop such programs as a multi-touch finger painting program or a kind of instrument-playing program. An example of a product that employs multipoint inputs is Apple's iPhone which uses capacitive technology to allow two touch sensor capability instead of the usual one. Michael envisions a much larger scale for this technology. "As computers go into different environments people are developing novel systems for interacting with the computer," Michael said.

Michael presented his prototype at the Stanford Undergraduate Research Symposium where people got to demo his photo program, and he is going to submit his research to a journal. In describing his research and future plans, Michael says, "It really got me interested in different modes of input into computers, and one fun part of the experience was building the specialized hardware, which is definitely not normal for computer science research. I definitely plan to continue to study different modes of computer input in the future and look forward to writing more programs that involve multipoint input."

MICHAEL FISCHER is a Senior at Stanford University majoring in computer science. He is interested in the theory of collaboration and how it can be applied to the Internet to promote innovation and creativity with large groups of people. Michael is also interested in applying computer science to problems in physics and mathematics. He plans to continue his computer science studies in these areas as well as in robotics, computer vision, and fiber optics. Michael's email address is mfischer@cs.stanford.edu.

Spotlight on Alexis Smith: Snuff Culture of Aristocratic Women in Antebellum America

Karis Tang-Quan[1]

Alexis Smith wanted her research to be "something new, exciting, and slightly edgy." She found snuff.

Snuff, one of the most popular recreational drugs in eighteenth- and nineteenth-century America, is a powdered tobacco inhaled through the nostrils and will be the subject of Alexis' thesis paper. Piqued by her "Global History of Tobacco and World Health" seminar led by Dr. Robert Proctor, Alexis' longtime interests in history evolved to include American tobacco culture as well. Even before her in-depth research into snuff began, Alexis had success with publication. She wrote an article titled "'Satisfiers,' Smokes, and Sports: The Unholy Marriage Between Major League Baseball and Big Tobacco" that was published in the November 2007 issue of the Sport History Review. After this initial article, Alexis wanted to integrate her love for American colonial history and her new found interest in tobacco culture. The result is her thesis on the social history of snuff.

Alexis researches the cultural history of snuff in antebellum America with a particular focus on the use of snuff by aristocratic women. She has found that middle-class men and women commonly used snuff for medical purposes. At the time, men condemned the "celestial powder" as an unladylike practice that made a woman unattractive. Despite the social disapprovement, upper-class women still sniffed the tobacco as a recreational drug in private and social settings with female company. Such American elites to use snuff were Abigail Adams and Dolley Madison. The drug culture of snuff in America was prolific yet underground, as Alexis discovered.

Due to the unspoken nature of the use of snuff in eighteenth- and nineteenth-centuries and the creativity of her research focus, Alexis initially struggled to find sources for the foundation of her study. She is one of the first and only persons to study the history of snuff in the United States, as it was a taboo subject of its time. As only a small number of researchers know about snuff, even fewer take the time to learn about the effect of snuff on the lives of the American aristocrats. With a limited scope of secondary sources, Alexis relied on online databases for her primary sources. Through these primary sources, she was able to understand snuff in its historical context, prior to the invention and popularization of the industrial cigarette roller in 1880. Such online archives as The North America Women's Letters and Diaries, Eighteenth Century Collections Online, and the Dolley Madison Digital Edition have proved invaluable to Alexis during her research.

While Alexis turned to primary sources for most of her information, she found that these could be lacking as well. There was little primary source evidence to be found of American in the physical act of sniffing. Alexis raised even more questions during this phase of her research progress: "Why did Americans omit the social rituals of snuff from their written history? Was pinching snuff such a mundane activity that it did not merit mention?" Alexis met the most challenging aspects of her research by forming more questions and re-directing her original hypothesis.

Alexis has overcome the many obstacles in her research that have arisen due to its unique nature. Since she is researching a very narrow field with very few colleagues to collaborate with, Alexis hopes her thesis "will serve as a springboard for other scholars interested in a snuff sub-culture." With previous work exhausting the history of pipes, chewing tobacco, and cigarettes, Alexis is at the forefront of American history research by uncovering the snuff culture of women in antebellum America. She unloads the secrets of aristocratic living to draw possible parallels to the drug culture of today's socialites. Alexis has realized that people are surprised to hear that Dolley Madison was one of the initial trendsetters responsible for popularizing snuff, and so uses this fun fact to draw people's interest. While many Americans today may not know what snuff is, Alexis brings the history of snuff culture to the present.

Alexis graciously points to the mentorship of Dr. Caroline Winterer as a reason for her research success. Dr. Winterer, an assistant professor in the Department of History and the Director of History Department Honors

Figure 1: Painting of Mrs. Richard Alsop holding a snuff handkerchief and silver snuffbox by American artist Ralph Earl in 1792. A bold and taboo statement of its time, this painting is one of the few existing images of a woman with snuff paraphernalia. (Elizabeth Mankin Kornhauser, "Mrs. Richard Alsop, 1792," Ralph Earl: The Face of the Young Republic (New Haven: Yale University Press, 1991), 45.)

[1]Stanford University

Program, is a leading researcher on the pre-20th century cultural and intellectual history of America and the transatlantic. Alexis has the privilege of studying with Dr. Winterer as well as Dr. Hilton Obenzinger, associate director of the Hume Writing Center, and Dr. Benjamin Stone, curator for American and British History at Green Library. In her Writing the Honors Thesis (PWR 193) class, Alexis has benefited from the support of her peers in writing her research thesis. She plans to present her finished research thesis to the History Department in May in addition to submitting a paper for publication to scholarly journals specializing in American cultural history.

When she began her research in the culture of snuff tobacco in antebellum America, Alexis did not did know where she would end. Her participation in undergraduate research has given Alexis the opportunity to make a lasting, first-hand contribution to her field of study.

ALEXIS SMITH is a senior preparing to graduate with honors from the history department and a minor from the Spanish department. Originally from Portola Valley, California, Alexis enjoys working as the House Manager in Kairos Co-Op and a Stanford campus tour guide. In her spare time, Alexis plays golf, hikes in the foothills, cooks for friends, gardens, and practices her Spanish and Portuguese.

Spotlight on Lucas Berla and Sam Rosenthal: Materials for the Future

Michael Tamkin[1]

One of the most innovative areas of research at Stanford occurs in the Materials Science and Engineering Department, with students studying computing power, alternative energy resources, magnetic properties, and tissue engineering. Special Features is pleased to highlight two students who are doing cutting-edge research. Senior Lucas Berla has been working with Materials Science and Engineering Professor William Nix to model hillock growth in integrated circuits, a complex phenomenon that can lead to circuit failure. Senior Sam Rosenthal, as part of Materials Science and Engineering Professor Michael McGehee's team, has been researching organic photovoltaics, solar cells made out of organic materials that could enable the production of renewable energy at a price lower than coal. I first spoke with Lucas about his research.

Q: What is your research topic?

***Lucas*:** Integrated circuits, such as those in computer microprocessors, are fabricated at high temperatures. Normally, integrated circuits operate at room temperature, so these circuits must be cooled dramatically following fabrication. This cooling process may give rise to invasive processes that can damage the metal films in the circuits. I studied one of these processes: hillock growth. Hillocks are protrusions that grow out of the surface of a metal. After the circuitry is cooled, hillock growth proceeds as a means of stress relaxation. Hillock growth is problematic, as it often leads to dielectric cracking and thus creates shorts in integrated circuits. This is a really big problem in the microelectronics industry and any company that manufactures integrated circuits, such as IBM, Intel, and AMD, has to worry about hillock growth.

Q: How did you become interested in this topic and what kind of work have you been doing?

***Lucas*:** I started working with Professor Nix the summer after sophomore year in 2006. I was really interested in his research on solid state nanomechanics. I applied for a VPUE grant for summer research in the Department of Materials Science and Engineering. One member of our team, a visiting professor from Korea, obtained experimental hillock growth data that spurred my specific project. Professor Nix and I began working to theoretically model hillock growth. Initially, I spent a lot of time working to understand an earlier paper on hillock growth written by Dr. Praveen Chaudhari. After we finished formulating our model, I compared both Chaudhari's model and our model to experimental data in order to determine the successes and shortcomings of the two models. Last fall I began writing up our results for a journal, and it was recently accepted into *Material Science & Engineering: A*. I worked many hours a day for several weeks to write the first draft of the paper. It was a great experience through which I learned to write clearly about complicated topics that I'd studied for months.

Q: What applications are there for this research in the future?

***Lucas*:** Through our research, we have provided a mechanistic understanding of the hillock growth process. We hope that industry workers and researchers will utilize our model and our findings to work toward the suppression of hillock growth.

Q: How would you characterize your overall research experience and its affect on your future goals?

***Lucas*:** This research project was very challenging and also highly educational. The project has reinforced my desire to do graduate work in Material Science, as I have realized that a PhD will be necessary for me to continue to perform fruitful research. Also, through this research I've realized that I don't want to be a pure experimentalist; I'd like to find a balance between theory and experimental work. During my graduate studies, I will continue to study nanomechanics, but I hope to develop into a well-rounded scientist and not a specialist. Working with Professor Nix has been an incredible opportunity. One cannot ask for a better mentor. Although he helped me out a lot, he also wanted me to learn on my own. The most important thing I have learned is to never give up. I don't know how many times we ran into an apparent roadblock during our research endeavor. You have to put in creative thought to overcome obstacles, and such creativity will yield unexpected yet insightful results.

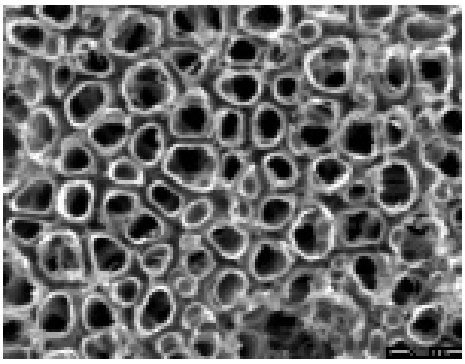

Figure 1: Scanning electron micrograph of anodic titania nanotubes on a transparent conducting oxide.

Q: What is your research topic?

***Sam*:** I work on organic photovoltaics. Due to the unique nature of the organic materials used in these devices, they could potentially be manufactured at far lower costs than conventional solar cells. However, they also pose significant new challenges that must be overcome before they can be commercialized. In order to produce

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electrical power, two different materials are used: for solar cells like the ones I make, these are a semiconducting polymer, which absorbs light, and titania, which harvests electrons from the polymer. A polymer layer at least 300 nm thick is needed to absorb most of the light from the sun, but all of the polymer must be within 10 nm of the titania for charge transfer to occur, design constraints that may seem to be mutually exclusive. I am working to overcome this challenge by creating a titania nanostructure, consisting of an ordered array of tubes 300–500 nm long and 10–20 nm in diameter, which could be filled with a semiconducting polymer to create an efficient solar cell.

Q: How did you become interested in this topic and what kind of work have you been doing?

***Sam*:** Solar energy research is the most promising pathway to a renewable energy solution that I know of, so I was very excited to have an opportunity to contribute to the field. I started working with Professor Mike McGehee the summer after Junior year, and he's had the idea of using ordered titania nanostructures for organic photovoltaics since he first came to Stanford. It was an attractive project because there were so many interesting physics and engineering problems to investigate. The approach I'm using now is based on literature that was found by Brian Hardin, a graduate student in the group. I've been anodizing thin films of titanium to create the titania nanostructures that I need. My work goes through cycles of about a week. I start with a transparent conducting oxide and deposit various materials on top of it, finishing with 500 nm of Ti metal. This then goes into an acidic bath with a strong electric field, which anodizes the metal, creating densely-packed titania nanotubes. I crystallize these tubes by heating them overnight, and then look at the resulting structure using a scanning electron microscope.

Q: How has your project evolved and what challenges have you faced?

***Sam*:** Now that I can make these titania nanostructures, my most significant problem is large particles that form sporadically on the surface of the film. I've been able to analyze their composition and determine when they appear, but I don't know what causes them. Currently, I'm working on various options to prevent them from forming or to remove them once they appear.

Q: What applications are there for this research in the future?

***Sam*:** The hope is that one day organic photovoltaics could be used to provide inexpensive renewable energy. Today, they suffer from low efficiencies and short lifetimes. If these problems can be overcome, organic solar cells may replace coal as the least expensive energy source, completely changing the way that the world gets its power.

Q: How would you characterize your overall research experience and its effect on your future goals?

***Sam*:** I think it's been a great research experience. I've gotten to work independently, designing experiments and thinking about how to approach this problem. It's been a really good first step towards a research career, and I plan on going back to school for a doctorate after a year or two off. Next year I'll be working for a solar cell startup founded by my advisor's first graduate student. Until then, I'll keep working on this project so that I can publish the results or hand it off to a graduate student in the group. The field of organic photovoltaics is relatively new and there are many questions that haven't been answered yet. I've been able to work on one of them.

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SAM ROSENTHAL is a senior in Materials Science and Engineering, with a focus on the electrical and optical properties of materials. Over the past two years, he has conducted research to develop several solar cell technologies, working with Professors Alberto Salleo and Michael McGehee. After a year working with a local photovoltaics startup, Sam plans to enter a doctoral program in Materials Science.

The Incongruence of the Schopenhauerian Ending in Wagner's Götterdämmerung

James Locus[1]

In Richard Wagner's four-part musical drama, The Ring of the Nibelung, the composer experienced great difficulty in completing the final draft of the last piece, the Götterdammerung. Before the music had been composed, the text of the piece – the libretto – remained incomplete for many years. Wagner planned five endings, yet one is particularly distinct in terms of context and philosophical underpinnings. Musicologists later labeled the unused text as The Schopenhauer Ending to reflect how strongly the philosophy of Arthur Schopenhauer influenced Wagner during the libretto stage. Focusing on the libretto, Locus explores Wagner's preoccupation with Schopenhauer's work and the way in which it inspired an ending, incongruent with both the larger context of The Ring of the Nibelung and the prevailing culture of Wagner's time.

Introduction

Richard Wagner's The Ring of the Nibelung epitomizes the pinnacle of the romantic Western tradition of music composition. The musical drama[2] in a prelude and three episodes recounts the events leading to the fall of the gods and the tragic, interwoven fates of its characters. Spanning four nights, the sixteen-hour production took twenty-six years to complete, resulting in several versions - each offering its own insight into the compositional process of its creator. The final scene of the last work, the *Götterdämmerung*, is one such example, requiring five significant attempts to arrive at a suitable ending.

The Ring has a complex narrative. The plot details how a stolen magical piece of jewelry affects the lives of a lineage of gods across several generations. Early in the narrative, a ring is forged with gold, stolen from the three Rhinemaidens. It possesses great power, thereby granting its holder the ability to dominate the world - if they so choose. This incredible potential attracts many power-hungry suitors, leading to a long trail of deceit as each attempts acquisition of the ring. Wotan, chief of the gods (and male protagonist for much of the story), is among the first to be ensnared by this lust for power. His flaw, then, proceeds to haunt his descendants as treachery and lies wreak havoc upon his once orderly world. It is not until Wotan's daughter, Brunnhilde, returns the ring to its owners and destroys the world of the gods after the death of her lover that the history of deception ends. The moral of the story speaks to the redemptive power of love in overcoming the lust for power.

A close reading of the various endings reveals Wagner's struggles as he associated himself with and, then, disassociated himself from an increasingly philosophical tone. This shifting is particularly evident in the later revisions of Brunnhilde's final monologue in the final act of the *Gotterdammerung*. Of these, the *Schopenhauer Ending*[3] departs strongly from both the *Final Published Ending* and other rejected endings. Its change in tone and structure warrant investigation as it indicates a significant shift in the artistic will of the composer.

The revisions address the libretto and stage directions, which are the focus of the entire drama's final scene. Brunnhilde, Wotan's former guardian and daughter (also the leading female protagonist), stands over the body of her slain lover, Siegfried. He has been tricked and killed as a result of the gods' desire to obtain the power held within the accursed, but mighty ring. At this moment, Brunnhilde begins a monologue, expressing her emotional response to the events before bringing the drama to a close. The central difference between the versions lies specifically in her words and actions. The words had to be chosen with extreme care in order to elucidate the composer's artistic vision. Yet, in these final moments, Wagner appears to struggle with the philosophical implications of the ending rather than with how compatible and well integrated it would be with the work as a whole. In his penultimate revision, Wagner's reverses his stance, underscoring the redemptive power of love, in favor of Arthur Schopenhauer's view, emphasizing love's meaninglessness and base sexual nature.[4] But why does Wagner stray from his central theme, affirming love, and adopt Schopenhauer's disparate vision?

In this essay, I argue that Wagner's attraction to Schopenhauer's philosophy was a misdirection, which caused him to temporarily ignore the dominant element of love, present in the *Ring Cycle*. First, I consider the rejected endings and final published ending in overview, emphasizing their salient characteristics. Further, I examine the specific contrasts between the *Schopenhauer Ending* and its predecessor, labeled by historians as the *Feuerbach Ending*. Then, I focus on the way in which Schopenhauer's writing influenced Wagner, compelling him to draft an additional revision to an already completed text. Finally, I contrast Wagner's Schopenhauerian outlook with his final product to illustrate how Wagner finally divorces himself from a view, which devalues love, and returns to his original premise.

The Five Endings of the *Götterdämmerung*

In Wagner's *28 November 1848 Ending*,[5] Brunnhilde is notably more forlorn and agitated as she stands over the slain body of her beloved Siegfried. Valhalla, the great hall of the gods, still

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burns in the end; however, her final words have taken a more accusatory tone. She openly rebukes Siegfried for his refusal to heed her advice not to pursue unnecessary heroism. Nonetheless, she reaffirms her love for him.

> You overwhelming hero, how you held me in thrall! All my wisdom I had to forgo, for all my knowledge I gave to you what you too you did not use, - in your bold defiance you trusted alone...Let the fire that now consumes me cleanse the ring of its curse.

Afterwards, Brunnhilde frees the Nibelungs (the people of the underworld), hands off the accursed ring to the Rhinemaidens, and enters the flames.

By comparison, the *18 December 1848 Ending* adopts a decidedly more religious tone:

> Blessed atonement, I saw for the holy, sacredly and only gods! Rejoice in the freest of heroes! To the greeting of his brotherly gods, his bride is bringing him now! Depart without power whom guilt now shuns. From your guilt has sprung the blithest of heroes whose unwilled deed has expunged it: you're spared the anxious struggle to save your waning power: fade away in bliss before man's deed, before the hero whom, alas, you create! In the midst of your anxious fear I proclaim to you blessed redemption.

Here, the percolation of divergent theology begins to seep into Wagner's work. *The Ring* was not intended as a direct religious allegory; however, the imposition of phrases such as "[b] lessed atonement" and "holy, sacredly" do correlate with potent themes associated with religion. Further, the redemption of sin - a key element of Christian doctrine - parallels noticeably with the last words of Christ during the crucifixion. The notable similarities between the two scenes are striking and provide an interesting counterpoint to the mythology, on which *The Ring* is based.

The contrasting *December 1852 Feuerbach Ending* derives its name from a comparatively atheistic text. The name was applied by later musicologists due to Wagner's interests in Ludwig Feuerbach - a known critic of religion (particularly Christianity) in his time. Scholars believe Wagner to have read Feuerbach by the completion of his own article of 1849, "The Art-Work of the Future." Both Wagner and Feuerbach issued similar titles and arrived at similar conclusions, regarding the future of their respective disciplines. While Feuerbach believed that philosophy needed a radically new way of thinking to serve the future, Wagner expressed similar sentiments in regards to music.[6]

This view found its way into the *Feuerbach Ending*. In the drama's final moments, Brunnhilde asserts not only that the fate of humanity rests with humans themselves, but moreover decrees the death of the gods. She ends with the message; "love alone can be," underscoring the power of love to shape the future of humanity. Kitcher and Schacht write;[7]

> Religion for Feuerbach involves a kind of confusion, resulting in the projection of features of our own nature and of genuinely human life into an imaginary realm beyond this life and this world.

Feuerbach's view of religion, then, becomes an assignment of human characteristics to deities and other supernatural forces. Brunnhilde's emotional decree that humans rise to assume the place of the fallen gods reflects Feuerbach's view of sustainable belief, emphasizing human attributes over religious mysticism.

Wagner's *December 1852, Final Published Ending*[8] emphasizes the power of love and its importance in the coming world of the humans. Angered by the perpetual deceit, Brunnhilde burns down Valhalla, the hall of the gods, before immolating herself and her steed, Grane.

> Feel how the flames burn in my breast, effulgent fires seize hold of my heart: to clasp him to me while held in my arms and in mightiest love to be wedded to him! - Heiayoho! Grane! Greet your master! Siegfried! Siegfried! See! In your bliss, your wife bids you welcome!

The weight of the passage emphasizes *fire,* which suggests both the emotional fire of her love for Siegfried and the physical fire of the funeral pyre. Love conquers lust for power as Brunnhilde casts the ring back to its original owners, the Rhinemaidens, in order to ignite the passions of her heart.

In stark contrast to these other endings, including that finally published, the May 1856 *Schopenhauer Ending* departs markedly in tone and perspective. While writing *The Ring*, Wagner became immersed in the writings of a popular philosopher of the time, Arthur Schopenhauer. One of Schopenhauer's major contributions to philosophy is his work The World as Will and Representation, which is believed to have influenced Wagner in his creation of the last revision of the final scene. For his part, Schopenhauer was greatly influenced by Eastern religions, such as Buddhism, where suffering brings about enlightenment and, further, abnegation of life and will is one's ultimate goal.[9] Greatly simplified, Schopenhauer writes from a pessimistic view of the world as a place, filled with unavoidable suffering and where the most pertinent course of action lies in the seeking to obtain non-suffering or non-existence.[10] As the following excerpt reflects, Wagner incorporates this viewpoint into his final revision of last scene:

> I close behind me now: to the holiest chosen land, free from desire and delusion, the goal of

> the world's migration, redeemed from reincarnation, the enlightened woman now goes. The blessed end of all things eternal, do you know how I attained it? Grieving love's profoundest suffering opened my eyes for me: I saw the world end.

In essence, Wagner seems to bring contradictory philosophical and religious ideas to bear on the central idea of the affirmation of life through love, which he has already established throughout his cycle and ending.[11] Researchers associate this shift to his exposure to Schopenhauer toward the end of the libretto writing.[12]

The Schopenhauer Ending was completed after the plot and significant themes within *The Ring* had already been defined. Kitcher and Schacht write; "Wagner finished the entire Ring poem in December of 1852, nearly two years before he discovered Schopenhauer (in the fall of 1854)." Thus, Wagner was effectively adding new theories, incongruous to the work's original conception. Using Schopenhauer's view, love (the redemptive force in the narrative) becomes a source of suffering to be overcome. This emphatically contradicts not only *The Valkyrie* Act II Sc 4, in which Brunnhilde awakens to the power of love during her conversation with Siegmund, but also the *Final Published Ending* Gotterdammerung, Act III Sc 3, in which she announces "to clasp him to me while held in my arms and in mightiest love to be wedded to him."

Did Schopenhauer Distract Wagner?

Wagner's preoccupation with Schopenhauer may have contributed to his difficulty in settling on an ending. Moreover, the final moments of a massive work create the final impression, in which the composer crystallizes his point and by which the audience judges his entire cycle. The desire to find the "perfect ending" may have driven Wagner closer and closer to Schopenhauer as he revised the ending. Ultimately, Wagner did decide against using the text[13] to convey the philosophical message; instead, he chose to reinforce the dominant theme of love rather than suppliant it with Schopenhauer's theoretical excess. But why would Wagner follow Schopenhauerian philosophy in the first place?

An examination of the *18 December 1848*, *Feuerbach*, and *Schopenhauer Endings* yields clues. The context and cultural presumptions of the respective texts draw from very divergent (and often distant) cultural presumptions. The *18 December 1848* and *Feuerbach* endings rely on religious motifs, while the *Schopenhauer Ending* rests on a particular philosophical interpretation of Eastern faiths. The first two would have been more accessible to the predominance of Protestants; [14] however, the latter requires a great deal of background in Schopenhauerian philosophy (or Buddhism) in order to fully grasp its significance. Juxtaposing the endings exposes Wagner's divergence into eastern philosophy while creating the *Schopenhauer Ending*.

Non-Schopenhauerian Endings as Alternative Ends to *"The Ring"*

The Non-Schopenhauerian Endings would have been more comprehensible to audiences of the time than the *Schopenhauer Ending*. These include the *18 December 1848*, *Feuerbach*, and final endings. Firstly, the characters in Norse mythos are reasonably explained throughout the onstage drama and text of the cycle. Further, in regards to any religious references, Christianity (in particular Protestantism) and its strong connection to rising German nationalism were ubiquitous in 19th century Germany.[15] Wagner could safely assume his audience's knowledge of and exposure to common religious motifs.

For example, it is unlikely the audience would fail to associate either "[b]lessed atonement, I saw for the holy, sacredly and only gods! …In the midst of your anxious fear I proclaim to you blessed redemption" with Jesus' crucifixion in Mark[16] Chapter 15 and Matthew 27 or the absolution of sin through redemption presented in Luke 24 and Mark 16. Framing the ending within a religious context would have allowed for increased comprehensibility for people with an understanding of the New Testament.

However, an ending, relying on quasi-religious premises, wasn't essential. In fact, by pursuing the *Final Published* version, Wagner could retain the central theme of the power of love. Recapitulating love's strength highlights Brunnhilde's struggle and loss of Siegfried while, also, reminding audiences of the undying relationship between Siegmund and Sieglinde. After all, love is a dominant feature in *The Ring*, present throughout the entire composition.

So why did Wagner try to integrate potentially antithetical philosophies into the ending two years after he had already finished the original libretto?

Why Schopenhauer?

Wagner was led astray by his adoration of Schopenhauer's conception of music as a high art form. Also, Wagner, influenced heavily by religious discussion, undoubtedly found rich intellectual discourse in the works of Schopenhauer,[17] a popular philosopher of the era. The composer followed the philosopher into the realm of religious contemplation. As Schopenhauer sought to comment on the spirituality of his contemporaries,[18] so too, did Wagner seek to reflect on important conceptions of music and their affect on the audience.[19] Though deeply drawn to theological and philosophical considerations, Wagner was chiefly a composer and, ultimately, could not place musical considerations beneath rival endeavors. Nevertheless, Schopenhauer's philosophical

frameworks appealed to Wagner's artistic sensibilities - regarding art as the intersection of Science and Life: [20]

> The Art-work, thus conceived as an immediate vital act (*its immediate physical portrayal, in the moment of its liveliest embodiment*), is therewith the perfect reconcilement of Science with Life, the laurel-wreath which the vanquished, redeemed by her defeat, reaches in joyous homage to her acknowledged victor.

As both composer and philosopher, Wagner could benefit from a Schopenhauerian understanding of Art.

One popular presumption as to why Wagner channeled the philosopher as a direct source of inspiration springs from Schopenhauer's concept of music. Schopenhauer's philosophy places music above other fine arts forms because of its ability for pure expression. In this view, music communicates an idea as the idea itself, whereas other art forms are mere representations of abstract notions, expressed through a medium.[21] Thus, the listener is more directly connected to the thoughts of the artist without obfuscation. Wagner writes;[22]

> But it was Schopenhauer who first defined the position of Music among the fine arts with philosophic clearness, ascribing to it a totally different nature from that of either plastic or poetic art. He starts from wonder at Music's speaking a language immediately intelligible by everyone, since it needs no whit of intermediation through abstract concepts *(Begriffe)*; which completely distinguishes it from Poetry, in the first place, whose sole material consists of concepts, employed by it to visualise the *Idea*.

This belief - that music is the highest art form - is consistent with Wagner's later writings, where he goes even further to relate music to human existence. To approach music with this idea became necessary to Wagner before embarking on a work of such phenomenal length as *The Ring*[23]

> Music speaks out Gesture's inmost essence in a language so direct that, once we are saturated with the music, our eyesight is positively incapacitated for intensive observation of the gesture, so that finally we understand it without our really seeing it… enabling [our senses] to grasp the Essence-of-things in its most immediate manifestment, as it were to read the vision which the music had himself beheld in deepest sleep[24]

The above similarities in thought seemingly had the effect of compelling Wagner through a Schopenhauerian exploration of eastern belief systems, which was unfamiliar territory to the German Christian audience. More significantly, this exploration led Wagner to introduce unestablished, incongruent philosophic ideas into his nearly completed narrative.

Perhaps the fact that Schopenhauer's perspective allowed Wagner to perceive old characters in a new light enthralled the composer. As Roger Hollinrack muses;[25]

> Might not the god's retreat in the face of a deterministic necessity be construed as a moral advance? His abandonment of his quest of power as the attainment of a higher metaphysical end?

Perhaps we should not see Wagner's work (prior to his late discovery) as anti-Schopenhauerian. Many of his major characters, including the central protagonist Wotan, cast shadows of Schopenhauerian ideals.[26] Tested with hardship and hardened through experience, Wotan could be seen as embodying Schopenhauer's idea of suffering being interwoven into the life. Wotan's renunciation of power in the later episodes of the drama even suggests an unintentional allusion to Schopenhauer's philosophy of suppressing the will to live in order to attain true wisdom. Wotan's renunciation of power led him not to destruction or despair – but rather to the end of his suffering as an "obsolete" god. Could not Brunnhilde's loss of her lover Siegfried and subsequent immolation also free her from earthly misfortune?

This interpretation would agree with Schopenhauer's philosophy and could be retroactively adapted to the story, providing a new way of understanding significant events. On 5 February 1855 Wagner writes, "My experiences of life has brought me to a point where only Schopenhauer's philosophy could wholly satisfy my and exert a decisive influence on my whole life." [27] It is at this point that Wagner begins the Schopenhauerian voyage, which diverts him from his central theme - the power of love – and nearly prompts him to renounce it altogether.

Conclusion

Richard Wagner, as a thinker and musician, was stimulated by Arthur Schopenhauer's philosophical writings. Yet, this influence proved counterproductive to the production of *The Ring* as the composer began to explore philosophies, which reduced the strength of the central theme of the cycle: the redeeming power of love. Wagner's brief detour into the Schopenhauerian stream of consciousness resulted in an unused ending to the *Götterdämmerung*, which proved ultimately incongruent in terms of contextual significance.

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Endnotes

1 Wagner began several less substantial drafts of other endings; however, for the purposes of analysis the essay focuses only on the most richly developed five.

2 Wagner preferred the use of the term "musical drama" to describe The Ring Cycle rather than "opera" due to its lack of traditional songs (as arias) and Wagner's methods of strongly integrating the orchestral music with the text into a single cohesive narrative. The cycle consists of four works; The Rhinegold, The Valkyrie, Siegfried, and Götterdämmerung (Twilight of the Gods).

3 Wagner did not assign names to his various endings; rather they were assigned by subsequent scholars to differentiate between the numerous endings.

4 Kitcher, Philip and Richard Schacht. Finding an Ending: Reflections on Wagner's Ring. Oxford University Press (2004) 19

5 Spencer, Stewart and Barry Millington. Wagner's Ring: A Companion. Thames and Hudson (1993) Appendix, Rejected Versions. The same source is used for all endings.

6 Kitcher, Philip and Richard Schacht. Finding an Ending: Reflections on Wagner's Ring (2004) 16

7 Kitcher, Philip and Richard Schacht. Finding an Ending: Reflections on Wagner's Ring (2004) 15-16

8 Spencer, Stewart and Barry Millington. Wagner's Ring: A Companion. Thames and Hudson (1993) 350-351

9 Kitcher, Philip and Richard Schacht. Finding an Ending: Reflections on Wagner's Ring. Oxford University Press (2004) 17-24

10 Ibid.

11 Ibid.

12 Ibid.

13 Some musicologists believe the Schopenhauerian Ending to have survived within the music during the final composition process.

14 Lehmann, Hartmut. The Germans as the Chosen People: Old Testament Themes in German Nationalism. German Studies Review (1991) 261-273

15 Ibid.

16 All Gospel passages used are from the Kings James Version of the Bible. The Bible is one of the main historical texts of Christians through which the majority of the faith's religious allegories and beliefs are derived.

17 Weinel, Heinrich. Wagner and Christianity. *The American Journal of Theology*, Vol. 7, No. 4. (Oct., 1903) pp. 609-634 Schopenhauer, Arthur. Religion: A Dialogue and Other Essays, The Christian System. Translated by T. Bailey Saunders. Ayer Company Publishers (1890) 103-118

18 Ibid.

19 Weinel, Heinrich, p. 610.

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26 Kitcher, Philip and Richard Schacht. Finding an Ending: Reflections on Wagner's Ring. Oxford University Press (2004) 18-19, 22

27 Letter to Rockel, 5 February 1855. Source provided by: Hollinrack, Roger. Epiphany and the Apocalypse in the Ring. Wagner's Ring of the Nibelung. Thames & Hudson (1993) 45

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He would like to express his sincere gratitude to Karol Berger, Erick Arenas, and Jessica Balik for their guidance and critiques that helped shape his academic development.

The Rise to Prominence of British Fashion in the 1960's: Economic, Cultural, and Political Foundations

Marissa Klein[1]

Although British fashion writers in the 1940s argued that England's strong textile and tailoring traditions would be the sole factors determining the international prominence of British fashion, it was, in fact, English designers' and consumers' willingness to turn their backs on established traditions and to capture the mood of the new era—a move that propelled British fashions to previously unseen heights. A new spirit of artistic innovation took root in a British society that was more youthful, affluent, politically liberal, and egalitarian, and Britain rose to dominate the world fashion scene in the 1960s. In tandem with the Beatles' music and the new pop art, innovative British fashions were exported throughout the world. However, this dominance could not and did not last, as the "mod" youth culture evolved into the flower-power, hippie scene, and other countries caught up with Britain and became fashion centers in their own right. Nonetheless, British fashion, with its characteristic turn towards youth and equality, continued to assert itself through other movements including Punk in the 1970's and Rule Britannia in the '90s, assuring that British fashion would not return to its staid past.

In 1945, Alison Settle of the British magazine *Picture Post* asked: "London: can it be a world fashion center?"[1] Her conclusion was that England's strong textile and tailoring traditions would allow it to take a prominent role in fashion, "provided always that she keeps to tailored suits and coats, to sports clothes, clothes of ceremony, and elegant yet not dressy frocks."[2] Within twenty years, England became the true leader in world fashion—but not simply because of its textiles. On the contrary, England rose to prominence and ended France's hegemony as a fashion capital because England turned its back on its traditionally tailored roots and embraced new ways. The primary reason for the rise of British fashion in the '60s was that its young, leading fashion designers catered to the youth. By designing for a younger crowd and eschewing the old-fashioned traditions of the establishment with new "mod" styles characterized, in part, by bright, flamboyant colors and innovative looks such as mini-skirts made from vinyl
for women and tight-fitting clothes for men, British designers and boutique-
owners ushered in a fashion revolution that captured the mood of the era and spread worldwide. With liberal politics and wider affluence than ever before, England was a ready for the change.

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1940's and 50's: Roots of the Fashion Revolution in Britain

Before experimentation in mod British fashion first began in the late 1950s, the only thing Britain was truly known for in fashion was an "inheritance of tailoring craftsmanship and the wonderful fabrics made in Britain."[3] While high fashion flourished for years elsewhere, patronized by the wealthy and celebrated by all, it enjoyed less support in Britain. Part of the reason for this was that "the powerful Protestant ethic traditionally militates against show and excess….The frivolity and hedonism associated with fashion goes against the perceived grain of Britishness."[4] Well-tailored suiting and classic, modest pieces fit with tradition in Britain. As opposed to Catholic countries with their long histories of lively pageantry and decadence, England had little support for bright fashion.

It was during World War II when Britain began to realize its own potential for growth in fashion. As the fashion leader throughout the modern period, Paris had created high fashion as an industry.[5] The basis of this fashion was *haute couture*, the most expensive and prestigious type of fashion. Translating literally as "high sewing or stitching," *haute couture* denotes garments that are custom-made to an individual's measurements, primarily by hand.[6] Couture existed outside of Paris as well, but until WWII, the best designers, whatever their nationality, all went to Paris and the most celebrated designs all came out of it. Within England, couture did not truly begin to appear until after WWI, as up until then English high fashion was restricted to the work of the court dressmakers of London's West End.[7]

During WWII, with Paris occupied by Germany, communication with the outside world about fashion was limited and other nations were forced to develop their own fashions. The 1942 founding of the Incorporated Society of London Fashion Designers, "the first organization to consolidate and co-ordinate the activities of Britain's high-fashion industry," was an important benchmark in the development of British fashion.[8] The wartime activities in the fashion industry whetted the appetite of British fashionistas to play a greater role in fashion instead of always deferring to the authority of the Paris establishment. Yet with the debut of French couturier Christian Dior's first collection, including the revolutionary New Look, British hopes were temporarily dashed.[9] With its full skirt and soft feminine shape , the New Look offered a complete contrast to the utilitarian clothes of the wartime and provided the dominant style for women's fashions through the 1950s.

Yet it was also in the '50s that British fashion first showed the signs of taking on a distinctive shape of its own—for this was the decade when the Teddy Boys

Dior's New Look. Source: New York City Fashion Geek Blog.

took to the streets and Mary Quant opened her boutique. Teddy Boys were the first youth fashion subculture of the post-war period, marked by working-class, macho young men who combined Edwardian dress with the American "zoot" suit.[10] They wore long sideburns, carefully coiffed hair, and were the first group of men to be preoccupied with shopping and appearance without sacrificing their masculinity. Meanwhile, Mary Quant opened Bazaar on King's Road in Chelsea, planting the first seed for the boutique experience.[11] She also gained

Teddy Boys in Manchester, 1955. Source: "1950 The Beginnings of Rock and Roll."

fame for inventing the mini-skirt and other mod fashions during the '60s, but a decade agoprior, she was already experimenting with simple, young fabrics such as poplin and gingham, unfussy designs that contrasted with the prevalent Dior-inspired trends elsewhere.[12] The British art schools long known for providing an excellent fashion design education to designers who would then leave to work in France, began to witness a shift, as the well-educated young designers increasingly stayed in Britain to lend their talents to their native fashion scene.[13]

Although there were economic problems lurking below the surface that would come to plague England in the late '60s and '70s, for the time being, at least, the average Brit enjoyed a period of affluence. Shorter working hours, higher wages, and a decreased birth rate meant smaller families with more money to spend.[14] If there was one group that most benefited from and reveled in these changes, it was the youth who came of age in the 1960s and who held the key to the triumph of British fashion.

1960's: Rise of the Youth Culture

After the war, birth rates had skyrocketed before they began to decrease in the 1960s, and "The peak of the post-war baby boom in 1947 meant that unparalleled numbers of teenagers reached puberty in 1960."[15] With new rises in affluence, these new teenagers also had more money to spend than ever before, and they loudly proclaimed their generation to show that they were different from their parents and grandparents. Clothes were the greatest expenditure of the young, and with boutiques that frequently changed their merchandise, there were always new styles to browse and buy.[16]

Caring little about the Paris establishment or the traditions of couture, young people wanted fashion that distinctly reflected their generation. As opposed to the fashions of another youthful decade, the 1920s, where the youthful styles were worn by fashionable women of all ages, the young styles of the '60s were meant only for the young.[17] Not only was the "London Look" aimed at the young, it made them look even younger. Mary Quant was the first great innovator, and her simple, clean designs incorporated "the sort of garments and fabrics worn by children: skinny pinafore dresses, knee socks, leotards, black stockings, gingham, and flannel."[18] Much of what we think of as the mod look in fashion—including the mini-skirt or the use of plastic PVC (polyvinyl chloride) as a fabric—originated with Quant and spread from her Chelsea boutique Bzaar.[19]

Quant's clothes were not necessarily cheap but they were affordable—and for clothes that were the apex of fashion to be affordable represents a great step. Now, instead of fashion being divided along social class lines, the only dividing line that existed now was between the old and the young. Quant quipped that her clothes were "bought both by the daughters of dukes and the daughters of dock workers, but were intended to emphasize the distinction between her generation and that of her mother's."[20] Fashion reflected the idea that there was little place for the old aristocracy in the new world order. Instead, there was a new aristocracy based not on class but on style, which was populated by Quant and her "Chelsea set" of young artists, thinkers, show business-people, and other colorful figures.[21] Young Britain's rejection of class and wealth provided another key to its fashion ascent, for only by appealing to a wider audience, as opposed to the elite, could the fashion truly spread.

The Spread of British Fashion Worldwide: the Boutique

PVC raincoat and hat by Mary Quant, 1963. Source: Breward, 122.

The medium for the spread of this new fashion, and the common space for all of the young and fashionable, was the boutique. Although the boutique was coined in Paris, originally meaning the stores out of which couture designers sold limited lines of ready-to-wear, the boutique of '60s London was something distinct.[22] As opposed to *haute couture*, the term ready-to-wear refers to clothes that are made in pre-determined sizes and are available to be picked out, tried on, and purchased as-is from a retail outlet such as a boutique.[23] Although ready-to-wear was already prevalent in America with its large department stores, the British boutiques represented Europe's first inclusion of ready-to-wear as perhaps the principal part of international high fashion.

The space of the boutique in '60s England was almost as innovative as the fashions themselves: featuring an entire mod experience, with loud pop music, darkened interior, cutting edge art and décor, and an edgy display of clothes within the shop and in the windows that attracted buyers.[24] This represented an entirely new kind of shopping experience, with merchandise that was frequently rotated so shoppers could return frequently and find new garments. Shopping at boutiques was another of the key aspects that set British fashion apart in the '60s, for the boutiques provided both a conceptual and an actual physical place within which the young and fashionable rotated. The hip space of the boutique, with its integration of fashion, music, and art represented the entire point-of-view of the classless, young audience who came to the boutiques not only to buy clothes but also just to hang out and check out the scene. Boutiques sprang up around Mary Quant's Chelsea Bazaar, and particularly on London's King's Road and Carnaby Street.[25] The most prominent of these boutiques was Biba in Kensington, opened in 1964 by Barbara Hulanicki.[26] Biba was cheaper and its clothes were even more widely worn. The clothes were softer and more feminine and drew more influence from romantic, retro styles inspired by Victorian and Edwardian times or by '20s and '30s Hollywood.[27] Meanwhile, in Carnaby Street, another boutique-fueled revolution was happening in menswear, with tight-fitting, brightly colored clothing, as "almost overnight the British male changed from being perhaps the most conservative dresser in the world to become a peacock."[28] The boutiques were an integral factor in codifying the fashion of the '60s as an entire experience—and if it was a definable experience with a reproducible product, it was only one step farther to export it elsehere.

Even within the space of the boutiques, fashion went together easily with pop music and art decorating the stores. Thus, when a new kind of pop music made its way to America in the form of the Beatles, so too did fashion. Eagerly consumed by American fans, the Beatles look was born out of the look of the Chelsea dandy from the boutiques on Carnaby Street.[29] The background and the nuances of British '60s fashion was boiled down and lumped together as "mod," which Americans took to mean "anything new coming out of London, including elements as arbitrary as Lord Snowdon, Carnaby Street, restaurants, Mary Quant, nightclubs and Vidal Sassoon."[30] Although American fans did not necessarily fully appreciate the nuances of British fashion or, say, the distinction between Bazaar and Biba, their hunger for the looks and their eagerness for British culture were highly significant in terms of bringing British fashion to the world stage. Part of the reason that British fashions were considered the height of style in the '60s was that they were so widely recognized by so many people. Without the influence of the Beatles and the fact that the clothes were packaged together with the music and then exported, for example, the rise of the fashions might not have been as possible.

1970's and Beyond: Decline of British Fashion on the Worldwide Stage

Once British fashion took off, French designers were slow to follow its lead and to make the switch from designing for the elite to designing for a wider range of consumers.

Biba satin dress, 1969. Source: Breward 127.

As opposed to the young designers who had trained in British art schools and were happy to innovate and challenge their predecessors' status quo, "the Paris createurs came from a rather different background—most had trained at the Chambre Syndicale school and been apprentices or assistants to the great couturiers."[31] As Paris fell behind in fashion, its designers began to innovate to fall closer in line with the British model. Yet instead of rejecting the couture tradition entirely, as was the case in fashionable London, Paris reformed from within, with designers continuing to create for a *haute couture* market but also adding ready-to-wear to their repertoires—eventually using couture to advertise their designs but creating ready-to-wear as their main money-maker.[32] Enjoying more government and industrial backing than the British ever did, French designers bounced back from their period of decline and continued with these joint couture and ready-to-wear ventures on a greater scale than was traditionally possible in Britain.

By the beginning of the '70s, Britain was again becoming eclipsed as a world fashion center, partially as a result of France's regaining footing. Yet the beginning of the fall had also began to manifest itself from within British fashion. After 1963, when Quant's designs were so famous that they began to be mass-produced for the US market, there was a shift as Quant-style mod resolved into a different look defined by Hulanicki's Biba, which was based more on romanticism and nostalgia.[33] In 1966, Biba moved to larger Kensington premises to cope with higher demand.[34] Yet at this time, "as with other areas of pop culture, the demand for ever-evolving newness forced a distraction from innovation and invention towards a plundering and interpretation of historical styles."[35] The designers could not keep up with demand. With the fashions becoming more and more widespread, designers also had to lose some of their authenticity.

By 1967, there was also a new cultural atmosphere in Britain and elsewhere. In 1967, the *Daily Mirror* of London reported "The kooky kids of '66 have been replaced by the flower girls of '67. Swinging London is awash with Hippie fashions."[36] The mod, frenetic early '60s that centered squarely

on London was being replaced by a drug-fueled, psychedelic experience that had more to do with San Francisco's Haight-Ashbury district.[37] What had been a rise in affluence in the earlier part of the decade was receding into economic recession.[38] Mostly run by young designers who were inexperienced as business people, the boutiques increasingly could not survive. Lacking the business acumen or simply the interest necessary to survive and struggling beneath the weight of broad forces like recession and specific problems such as widespread shoplifting, the boutique era was largely over by the early '70s.[39] Meanwhile, as the stars of Paris, New York, San Francisco, and Milan rose, London now found that it could not keep up in terms of fashion. The Swinging Sixties and the dominance of British fashion were over.

Yet if the 1960s was the beginning for British fashion as a force to be reckoned with, it was not its end either. Before the '60s, Paris was the unquestioned apex of the fashion world; after London showed that fashion could come from elsewhere, the door was open for everyone else to question and grapple with Paris. After the '60s, trends could come and go in any of a half-dozen or more fashion cities and could capture attention away from Paris. Although London never again achieved prominence on the level that it had during the '60s, it was never again discounted as a fashion capital. Other fashion movements, such as Glam Rock in the early 1970s, Rule Britannia in the '90s, or perhaps most importantly, Punk in 1976, brought attention to London fashion.[40] London burned bright but fast during the 1960s, but its demise was not the end for the history of British fashion. Its turn towards youth and equality was exported everywhere, and it ensured that no matter what happened, British fashion would never again return to its staid, provincial past.

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Endnotes

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8. De La Haye:15.
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20. O'Neill A.
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22. Ewing:185.
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24. McRobbie A. 25. Waddell:32.
26. Peacock:63.
27. Breward:127-128.
28. Waddell:87.
29. Breward:128.
30. O'Neill:137.
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32. De La Haye:22.
33. Peacock:63.
34. Fogg:83.
35. O'Neill:142.
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38. Morgan:78.
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Flawed Poetry as Perfect Worship: George Herbert's 'Life'

Scott Coomes[1]

I MADE a posie, while the day ran by:
Here will I smell my remnant out, and tie
My life within this band.
But Time did becken to the flowers, and they
By noon most cunningly did steal away,
And wither'd in my hand.
My hand was next to them, and then my heart:
I took, without more thinking, in good part
Times gentle admonition:
Who did so sweetly deaths sad taste convey,
Making my minde to smell my fatall day;
Yet sugring the suspicion.
Farewell deare flowers, sweetly your time ye spent,
Fit, while ye liv'd, for smell or ornament,
And after death for cures.
I follow straight without complaints or grief,
Since if my sent be good, I care not, if
It be as short as yours.

George Herbert's poem "Life" comes into conflict with its early modern Christian context in its form and content. The content and the form each possess their own unity, but they present separate theses that become problematic once they are taken to their full conclusions. Through a combination of close reading, research into secondary criticism, and consideration of the historical context, it may be seen that these difficulties actually interact to propel the poem as a work of Christian narration.

George Herbert's poem "Life" appeared in the collection *The Temple: Sacred Poems and Private Ejaculations*. Herbert, as a priest, believed that through formal unity a work of art could become a type of worship. The poem describes the death of a handful of flowers and how they inspire the speaker to reflect upon his own mortality. This narrative seems fairly straightforward when read prosaically. However, the form and style of "Life" present ideas that undermine this cursory reading, making necessary another level of interpretation. Herbert's noted commitment to unity suggests there is perhaps another way in which his style could be said to match the content, one which would not necessarily establish a typical type of unity.

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According to the critic Joseph Summers, George Herbert's emphasis on form strays from the typical Protestant ideology of his time, for it focuses the poetry upon earthly images with its beauty. In the Augustinian mindset that influenced the Protestants, attention to any thing should always lead towards God. Herbert, however, believed in formal beauty because, as Summers writes, 'God should be worshipped in "the beauty of holiness, and He had shown…that the arrangement of 'objects of the senses' (whether things or words) into a pattern symbolic of divine order was the method of worship which pleased Him."[1] Formal beauty through aesthetic and ethical ordering could reflect the beauty of God. Let us examine the formal elements of "Life" to see how they carry out this project.

The basic formal unit of "Life" is the three line stanza, which repeats six times. For each stanza, the first two lines are parallel in metrical length and end rhymes, while the third line is spatially decentered, does not rhyme with the previous two lines, and has a separate metrical length. This asymmetry seems to frustrate a typical reading of the poem; the parallel first and second lines establish the beginnings of a flow only so that the third line will cut it off abruptly. Each stanza also forces a pause during reading, as the scanning pattern of the eyes will be interrupted as they are forced to jump across the page. The last line also veers off past the space occupied by the first lines, sending the reader into the margins. This does not mean, however, that the breakdown in form gives the poetry freedom, for the ruptures only stutter the momentum. The critic Vendler writes that the syntax of "Life" portrays a series of "dying falls," suggesting a termination at the end of each stanza, rather than movement outside of the verse.[2] Form is not an element of constraint, but the core of the poetry itself, and its breakage affects not only the structure but disrupts the flow of the poetry as a whole.

This seems to partially emulate the subject matter of the poem. Each "dying fall" is an instance of humble death and the repetition suggests a bouquet of flowers perishing one by one. Almost every third line also concerns some disappointment or type of decay: "And withered in my hand," "Time's gentle admonition," "Yet sug'ring the suspicion," "and after death for cures," and "it be as short as yours." The narrative, however, meditates upon the nature of time and ends optimistically, with the speaker at peace. This aspect of the content clashes with the violent disintegration of form. Although the "dying fall" structure fits the subject of the second and last stanzas, it seems inappropriate for the intermediary stanzas. Finally, the poem describes an intellectual movement across the dimension of time, while the form

repetitively acts out the cessation of progress. The formal aspects of "Life," then, do not seem to reflect the "beauty of holiness" at all.

This irresolution in form and its disunity with the content strains the Christian mindset behind the work, which focuses upon the afterlife as the ultimate meaning of bodily death. In the form of "Life," each stanza unit fails to point towards anything beyond itself, with only repetition of the same pattern. This would particularly have been inconsistent with Herbert's project of evangelization as a minister. Herbert believed that worship should be rational, meaning that every part needed to be understandable. Worship through comprehensible rituals could be a way to obtain grace; the ritualistic repetition of "Life" and unexplained inconsistencies, however, casts doubt upon grace itself.

Another problematic "argument" is the elevation of Herbert through his poetry, which contradicts the call for humility in his piece *A Priest to the Temple*. The first line of "Life" conflates the imagery of the poem with its manufacture: "I made a posie." "Posie" could be both taken as a flower and "poesy," which is further suggested by the ambiguity of "made," implying artful manufacture. The movement of the word "hand" spatially on the page also conflates the poetry with the speaker: "And withered in my hand. / My hand was next to them, and then my heart." When "my hand" appears in the "dying fall" of the previous stanza, it receives the metaphorical dying flowers. It then moves inward toward the mind (or "heart") of the poet. "My hand" literally draws the death of the flower to the self, or across the page while writing the poetry. The subject of the poem is its own writing and the personality behind it.

This focus on Herbert's presence within the poem seems problematic for the Christian context of the poetry, as "Life" does not point towards God, but revels in closed poetic satisfaction. James White believes that the poem presents a self-delusory speaker who is too accepting of the flowers' sweetness and their role as a mirror of his own salvation. He argues that the reader would not necessarily be led to further reflection, for the poetry depends on a "view of the self as unitary or coherent, which Herbert perpetually undermines."[3] White claims that the contradictions within the poem stall interpretation. The content, then, is just as fatal to reading as the form on its own.

Close analysis of the content reveals several inconsistencies in the seemingly straightforward vision of comfort in death. The position of the flowers is spatially confused, as they are "within this band," the object of "time," "by," "away," and "in." The distorted sense of time collapses the poem chronologically and the only linearity seems to be supplied by the process of reading. In addition, the speaker personalizes the dying flowers "without more thinking," implying that the metaphor works only through willing blindness. The apogee of the flowers' lives before they become a metaphor in death is their "smell and ornament," suggesting a frivolity to the "scent" that the speaker finds comforting in the final stanza.

Nevertheless, the faults of the verse could be seen as reflective of the theological thought behind the poetry. There has been a critical debate about whether Herbert intended for his poems to possess a spirituality in themselves or if they instead are meant to represent a certain type of spirituality or theology.[4] This reflects the Protestant discussion about transubstantiation and consubstantiation of the Eucharist. The critic Asals argues "the Eucharistic sacrifice in *The Temple*…is the sacrifice of language itself: the poetry is Eucharistic because it consecrates the 'creature' of language as the ontological bridge to the divine."[5] So far, we have encountered two visions within the poetry that defy Christian spirituality in the form and content. Both of these forces only not only make assertions opposed to Christianity, but to one another. This quote suggests, however, that there is a way in which the problematic aspects could assert Christian beliefs. The inconsistencies actually open up the poetry from closed completeness.

According to Stanley Fish, inconsistency is a poetic gesture in itself; he describes the poems of Herbert as "self-consuming artifacts," meaning that they undo the interpretations of the audience and undermine their own meaningfulness. Fish writes, "The tension between the two visions in Hebert's poetry—one dividing and specifying, the other resolving and unifying—is a tension between the 'I' of the speaker and reader and the 'all' of God."[6] He then speaks of the tension dissolving the divide between the two. In "Life," the inconsistency offered by the poetry becomes an instrument for releasing the work from its closed form and content, and for impinging upon this tension. The contrast between the saccharine metaphor of flowers and the nihilism of the form breaks open the poetry to the scrutiny of the reader which, as Fish suggests, could lead the reader to a spiritual vision.

The disagreement between form and content actually seems to imply a certain type of narrative. Julia Guernsey writes: "Two poetics are at work…: a poetics of mortification, which represents the…self as broken, decaying, thing-like, and a poetics of quickening, which represents the… self as whole and alive in relation to God."[7] Perhaps, then, the pattern of dying falls works as a positive formal aspect against the content. Herbert does not try to impose balance upon the subject by offering a resolution in each stanza. Instead, he captures the instability through repetition, suggesting a deliberate disorderliness to the poetry. The narrative flow turns the deformity into a type of rhythm. These dying falls also reach out to one

another not only through the pattern, but in their end rhymes. This dissolves the independence of each stanza as a formal unit. Instead, each stanza is united by the form that undoes them, hinting at a coherency to the pattern of death. Thus, the "dying falls" are not defects, but a spiritual argument associated with Guernsey's "poetics of mortification." The ideas put forward by the form could be seen as a thesis that engages the problematic content; the death inherent in the form engages the saccharine logic and over-full narrator. It would seem that the verses are too weak to make such a powerful counter argument. However, it is through the deficiencies that their true strength comes forth.

This is because the inconsistencies require the reader to approach the poem in a certain way to regain coherency after the style and content come into conflict. Wolfgang Iser argues that that the reader will manufacture a coherency in a text to compensate for the gaps.[8] These gaps, however, are not completely open for the intended audience, as they are guided by certain expectations. For Iser, these gaps are also filled in by appropriately by the "implied reader." In order to see how the distance between the form and the content is filled in and how the inconsistency is handled, let us examine the possible implied reader. While the poem itself does not spell out the comfort behind death, besides aestheticizing it as a symbol, the Christian audiences would expect a grace beyond the end of the poem. The reader must extend the Protestant reading to other aspects as well, For instance, Herbert implying that he failed to grasp the lesson of flowers completely ("I took without more thinking, in good part, / Time's gentle admonition"), could be admission of humility rather than as an endorsement of haphazard exegesis.

The reader can either find redemption in the poem or redeem its inconsistencies. Returning to the repetition of the "dying falls," this trope could be seen not as a nihilistic imitation of decay, but as evocative of Christian thought. According to Barbara Lewalski, the Protestants had a unique sense of typology that expanded upon that of medieval scholarship. Lewalksi writes, "This emphasis permitted Protestants…to regard history as a continuum rather than as two eras of time divided by the incarnation of Christ."[9] The notion of a type, then, combines repetition and history, both of which occur in the repetition of the "dying falls" across the verses. Previously, I had mentioned that the forms of stanzas had interfered with the momentum of reading. However, it may be seen that at the same time, the form of the stanzas actually *generates* a thematic momentum, or "continuum," in its interaction with the content.

This momentum of the form propels the logic of the poetry beyond the final line and the reader is invited to join into the action of the poem. In the final line, Herbert wishes that he could have a "scent" like the flowers; this same quality in prior lines was what had attracted Herbert to them aesthetically. This is a critical moment in the inconsistency of the poem, for Herbert desires what he had just admitted as frivolous and the possibly problematic identity of the poet is at stake. The sweetness that Herbert desires as his own could be seen as requiring another party to sense. If Herbert shifts his role to that of the flower, then another interpreter needs to take his place. This positions the reader in the same sort of relationship to Herbert as Herbert to the flowers. In the same way that Herbert blurs the distinction between "making" the flower and plucking it, the reader is likewise cast into the position of admiring the poem or remaking it through interpretation. At the same time, the typology of the style extends beyond the last line towards the reader herself.

Instead of submitting to the same deficiencies of the poem, the implied reader, importing the Christian narrative of typology, will introduce the subtext of grace and redemption. The ending implied by typology redefines the interpretation of the poem. Guernsey writes, "through dependence on an Other who knows and understands all the pieces, the Herbertian self comes together as a whole and viable person."[10] Thus, the poem is incomplete so that it can be assembled from the outside or by the gaze of the "Other" belonging to the reader that Herbert preaches to. This particular reading of "scent," then, will become a spiritual beauty. For although the speaker does seem sentimental enough to hope for a redemption through beauty, the reader, placed into the perspective of the interpreter, will be free to apply a Christian narrative to the ending so that the poem becomes formally whole.[11]

In this way, the distance between the style and the content can be closed through certain hermeneutic sutures. The dark irony of the title "Life" becomes absolved in the context of the poem because the Christian narrative will make it sincere as the reward of the speaker. Likewise, the reader will continue the pattern of "dying falls" as a type, but these formal faults cease to be problematic. Instead of seeing the stops in momentum as a sort of cessation of the life of the poem, the reader might see these opportunities for interpretation at each stage of reading.

This external building in itself is the affect of the poetry. Through this ordering of the poetry, by filling in the gaps with a Christian narrative, the reader actually takes part in the worship. Thus, the poem could be seen as not an 'ordering' of aspects of God's creation, but a presentation of their pieces with instructions as to how they may be arranged to reflect God's holiness. In this way, the poem avoids veering into idolatry and becomes instead a device for instruction and worship for the questioning reader.

Endnotes

1 Summers, Joseph. *George Herbert: His Religion and Art*. p. 74.

2 Vendler, Helen. *The Poetry of George Herbert*. p. 131.

3 White, James Boyd. *"This Book of Starres": Learning to Read George Herbert*. p. 222-3.

4 Veith, Gene Edward. *Reformation Spirituality: The Religion of George Herbert.*

5 Asals, Heather A. R., *Equivocal Predication: George Herbert's Way To God.* p. 6.

6 Fish, Stanley. *Self Consuming Artifacts.* p. 173.

7 Guernsey, Julia. *The Pulse of Praise.* p. 21.

8 Iser, Wolfgang. *The Act of Reading* and *The Implied Reader.*

9 Lewalski, Barbarak. "Typology and Poetry," from *Illustrious Evidence.* ed. by Miner, Earl. p. 43.

10 Guernsey, Julia. *The Pulse of Praise.* p. 128.

11 Fish writes, "Herbert's poetry… shares with the catechistical practice of his parson a shape and a goal: the goal is the involvement of the reader in his own edification…and the shape is the bringing of the reader 'by questions well ordered' to 'that which he knows not.'" (Fish, Stanley. *The Living Temple.* p. 27.)

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Nassau Grouper and Spiny Lobster Nursery Habitats at Abaco and Andros Islands in the Bahamas: Recommendations for New Marine Protected Areas

Laurie Kost[1]

The goal of this study was to identify potential nursery habitat for the Nassau grouper, *Epinephelus striatus*, and spiny lobster, *Panuliris argus*, at Abaco and Andros Islands, Bahamas for possible inclusion in marine protected areas. The Nassau grouper and spiny lobster are valuable to the fisheries industry and both species play key ecological roles as top predators in coral reef ecosystems. Using underwater videos, I classified benthic habitat along transects at Abaco and Andros and determined quantitatively percent cover of benthic species in selected areas of the transects. I focused on the distribution of the red macroalga, *Laurencia spp*., which is known to provide favorable nursery habitat for the Nassau grouper and spiny lobster. Video footage from both Abaco and Andros showed substantial benthic habitat with *Laurencia* spp. cover >30%. Median percent video time with *Laurencia* spp. cover >30% was over twice as high at Abaco (median 49%) than at Andros transects (median 18.1%). Seagrass, *Thalassia sp*., data are also reported, although the suitability of seagrass as nursery habitat for the Nassau grouper and spiny lobster is questionable. Seagrass was much more abundant at Abaco transects (median 53.5%) compared with Andros transects (median 5.5%). Based on *Laurencia* spp. cover, results of this survey show favorable habitat for the Nassau grouper and spiny lobster at primarily Abaco, which especially merits inclusion in a marine protected area.

Introduction

In 1999, the Bahamian government announced a plan to protect 20% of the Bahamian marine environment as no-take marine reserves.[1] Nursery habitats for two species of ecological and economic value, the Nassau grouper, *Epinephelus striatus*, and spiny lobster, *Panulirus argus*, will represent a significant component of the future marine protected areas. Both the Nassau grouper and spiny lobster are valuable fisheries species in the Bahamas region, and as top predators, both species can have a significant impact on coral reef ecosystem structure. My research is part of the Bahamas Biocomplexity Project (BBP), a five-year study funded by the National Science Foundation through the American Museum of Natural History. The intent of this interdisciplinary project is to assess the Exuma Cays Land and Sea Park, established in 1958, and to expand the network of marine protected areas throughout the Bahamas archipelago. Both the Nassau grouper and spiny lobster are known to spend early life history stages in near shore shallow water habitats.[2,3,4,5,6] Previous studies have reported an association of the early stages of both species with the red alga, *Laurencia spp*. The Nassau grouper spends late larval and early juvenile stages inshore in algal-covered coral clumps before moving to offshore coral reef habitats.[2,3,4] Dahlgren and Eggleston noted a disproportionately high association between Nassau grouper and *Laurencia spp*., whereas the association with other habitat types, such as seagrass, was found to be in proportion to habitat availability.[4] The spiny lobster also exhibits an ontogenetic habitat shift. It spends postlarval and early juvenile stages in benthic *Laurencia spp*. habitats.[5,6] *Laurencia spp*. provides protection from predators and also harbors a community of organisms that serve as a potential prey for the Nassau grouper and spiny lobster.[2,6] Eggleston determined that *Laurencia spp*. percent cover of 30% or greater represents a suitable nursery habitat for the Nassau grouper. [2]The goal of my research was to identify areas of Abaco and Andros Islands that contain suitable nursery habitat for the Nassau grouper and spiny lobster. This project was designed to classify benthic habitats along selected transects at Abaco and Andros based on predominant benthic biota, and to quantitatively determine percent cover of benthic species in portions of the transects. Of particular interest is the distribution of the red macroalga, *Laurencia spp*., because of its documented role as nursery habitat for the Nassau grouper and spiny lobster. Seagrass is known to serve as a nursery habitat for many marine species, but its importance as a habitat for young Nassau grouper and spiny lobster is uncertain.[2,7,8,9] In the present research, seagrass was a common habitat encountered and thus sea grass data are included in this report.

Methods

Field Work.

Benthic habitats were filmed at two islands in the Bahamas, Abaco (see Figure 1) and Andros (see Figure 2) by members of the Bahamas Biocomplexity Project team using the Manta Tow underwater method of Kenyon et al.[10] Two cameras, mounted on a tow board and operated by a SCUBA diver, were dragged behind a small boat. One camera was positioned at an oblique angle, pointing forward and downward at an angle of 45°. The second camera was positioned orthogonally downward. The orthogonal camera had two laser points separated by 21 cm that projected onto the bottom for distance

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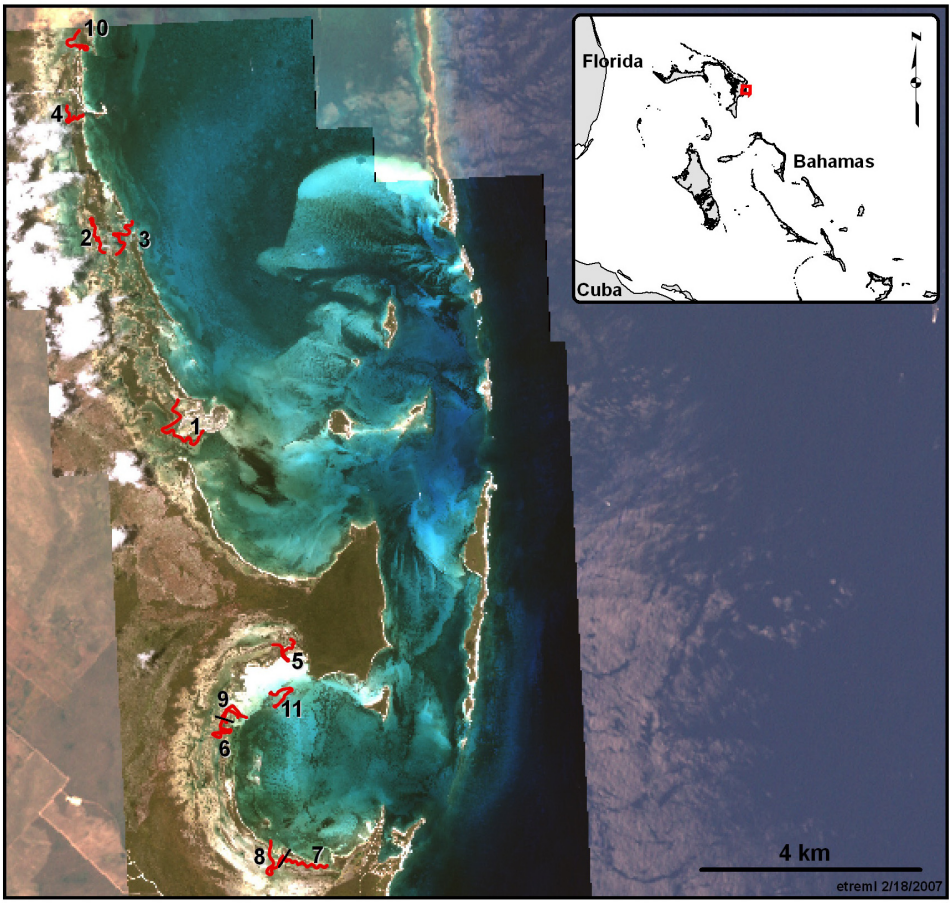


Figure 1: *Abaco Island Transect Locations.* Locations are: 1, Nurse Cay Creek; 2, Back South Collector Site; 3, Front South Collector Site; 4, Snake Cay Creek; 5, North Mangrove Channel, Bight of Old Robinson; 6, Central Cut, Bight of Old Robinson; 7, South Creek, Bight of Old Robinson; 8, South Cut, Bight of Old Robinson; 9, North Cut, Bight of Old Robinson; 10, North Collector Site; 11, North Rocks, Bight of Old Robinson.

orientation.

The oblique film provided a wider view of the ocean floor, suitable for habitat classification, while the orthogonal view provided a delineated quantifiable area for percent cover analysis. The video rate was 25 frames per second. The boat speed was 2 km per hour. The average transect was 1.2 km in length. Films were taken at eleven different locations at Abaco Island and at eight locations at Andros (see Figures 1 and 2). Filming on Abaco was performed in January 2006 and on Andros, in July 2006.

Habitat Classification

After converting the films to .avi format and uploading them onto a computer hard-drive, I used Adobe® Premiere® Pro Version 7 software to view frames. Each frame of the oblique films was classified as one of 15 different habitat types. Suitable nursery habitat was previously defined by the Bahamas Biocomplexity Project as areas having ≥30% *Laurencia spp*. cover, based on research by Eggleston on Nassau grouper in the central Bahamas.[2]

A habitat identification flowchart (see Figure 3) developed by BBP researchers guided the habitat classification procedure.[11] The habitat types used in this study are based on previous work by Mumby and Harborne Eggleston and Mulholland-Olson.[2,11,12]

Once the first frame of a video was classified as to habitat type, the video was played until a new habitat was encountered. The new habitat was identified and the time noted. The entire video was analyzed in a similar manner. Total oblique video time for each habitat type was computed for each island. Total video time with *Laurencia spp*. cover ≥30% was computed for each transect at each island. Likewise, total video time with seagrass cover ≥30% was computed for each transect at each island. For habitat classification analyses, comparisons were based on video time rather than area because the oblique video provided a panoramic view and was not designed to produce quantitative area data.

Percent Cover Analysis

After performing habitat identification on the oblique videos, the orthogonal videos were used for quantitative percent cover analysis. Using a random number generator, video frames were randomly selected from the oblique videos taken at each island, which corresponded to frame times on the orthogonal videos. The frames selected for the percent cover analysis were proportioned according to the abundance of habitat types encountered in the analysis of oblique views. For example, if 15% of the oblique film frames at one island were classified as "*Laurencia spp*. and *Laurencia spp*.", then 15% of the 400 random orthogonal frames from that island would be randomly selected from "*Laurencia spp*. and *Laurencia spp*." habitats. If a habitat type was observed less than 10% of the oblique video time in all videos for a particular island, a minimum of 20 sample frames were randomly chosen from the total frames of that habitat type. Incongruence between the orthogonal and oblique videos due to fogging of the video lens or other technical difficulties required

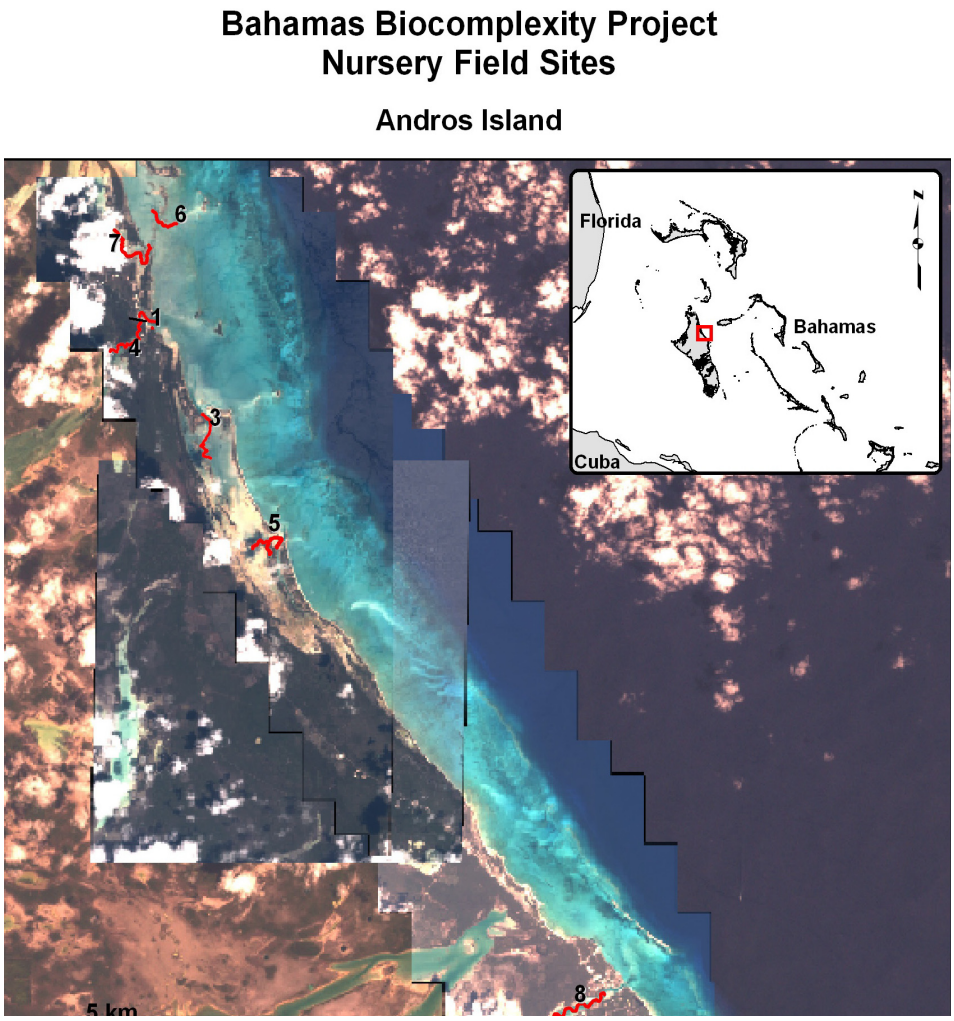


Figure 2: *Andros Island Transect Locations.* Locations are: 1, Stafford Creek; 2, Stafford Creek; 3, Blanket Sound; 4, Stafford Creek Middle; 5, Staniard Creek; 6, Saddleback Cay Channel; 7, London Creek; 8, Fresh Creek.

adjustments in alignment of video times.

The randomly selected orthogonal frames were analyzed for percent cover of benthic biota using the computer program, Vidana.[13] The camera laser points representing a fixed distance (21 cm) were used to delineate a square quadrat on the computer screen. On each frame, benthic species seen in the quadrat area were colored on the computer screen. From the colored areas on each frame, the Vidana program computed percent cover for benthic species represented by each color. Median percent cover by *Laurencia spp*. was determined for the six habitats that contained *Laurencia spp*.

Results

Video analysis demonstrated the presence of nursery habitat at both Abaco and Andros Islands. The distribution of the 15 habitat types differed markedly between the two islands (see Figures 4A and B). Medium and dense seagrass habitats, with or without *Laurencia*, were much more common at Abaco. The *Laurencia* dominated habitat was also more prevalent at Abaco. Batophora habitats, with or without *Laurencia*, were more common at Andros. The mixed macroalgae habitat and *Sargassum* habitat were also more common at the Andros transects.

Although all transects at Abaco had areas where *Laurencia spp*. cover was ≥ 30%, there was notable variation in the occurrence of *Laurencia spp*. (see Figure 5A). The transect with the greatest percent of video time (90.7%) with *Laurencia* cover ≥30% was Transect 8, South Cut, Bight of Old Robinson. (For simplicity, the phrase "*Laurencia* cover" is used in place of *Laurencia spp*. cover ≥30%.) At the Bight of Old Robinson, the northern most transects in the bay had much lower *Laurencia* cover (Transect 5, 9.9%; Transect 11, 12.1%) than the four transects to the south (Transect 6, 57.7%; Transect 7, 49.0%, Transect 8, 90.7 %, and Transect 9, 60.2%). Two transects at the South Collector Site, although less than 1 km apart, had very different *Laurencia* cover (Transect 2 South Collector Site Back, 81.5% and Transect 3 South Collector Site Front, 11.3%). The transect numbers indicated after the station names in Figures 5 and 6 can be located on the transect maps in Figures 1 and 2.

The percent of video time with *Laurencia* cover ≥ 30% was over twice as high at Abaco transects (median 49.0%) than at Andros transects (median 18.1%) (see Figures 5A and B). Two transects at Andros, Transect 4 Stafford Creek (Middle), and Transect 2 Stafford Creek, had no video time where *Laurencia* cover was ≥30%. Of the Andros transects, London Creek, Transect 7 had the greatest *Laurencia* cover (66.7% of video time).

Although *Laurencia spp*. cover was the focus of this research, seagrass, Thalassia sp. was a common habitat type encountered. Therefore, habitat classification information for seagrass at Abaco and Andros is included in this report. The median percent of video time with seagrass cover ≥30% was notably higher at Abaco (median 53.5% of video time) compared to Andros (median 5.5% of video time) (see Figures 6A, 6B). The greatest amount of seagrass cover was

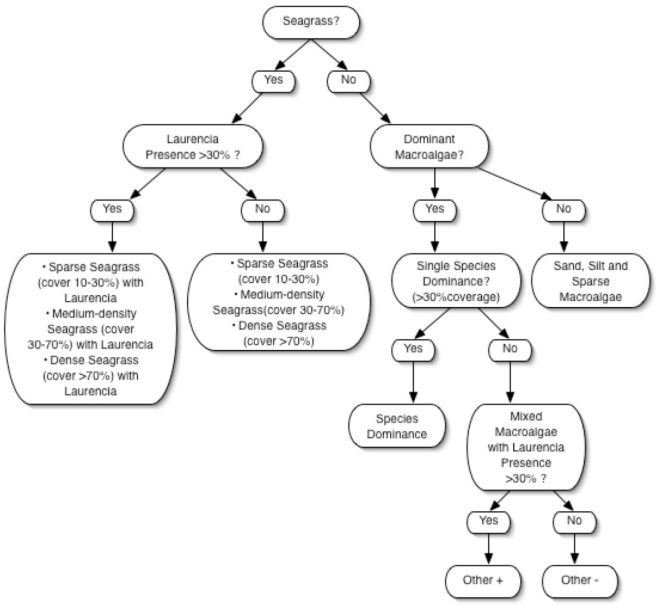


Figure 3: Habitat Identification Flowchart.

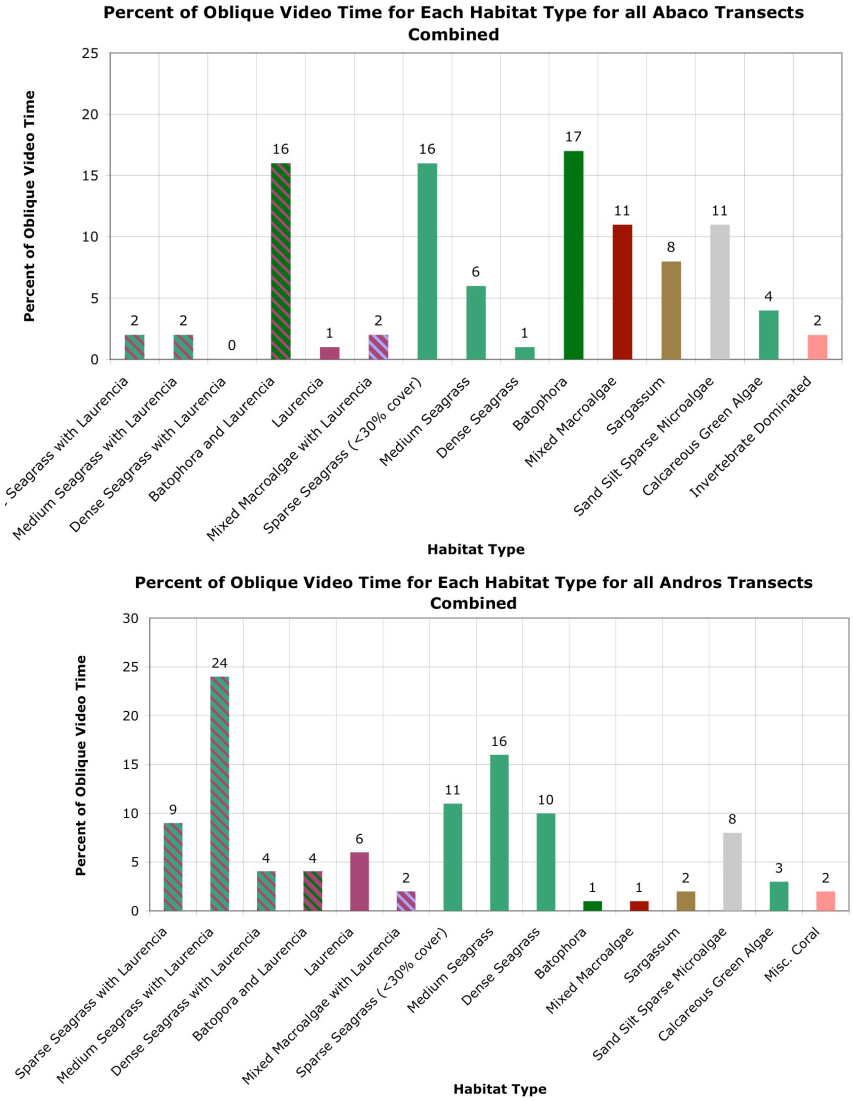


Figure 4: Percent of oblique video time for each habitat type for all Abaco Island transects combined (top) and for all Andros Island transects combined (bottom).

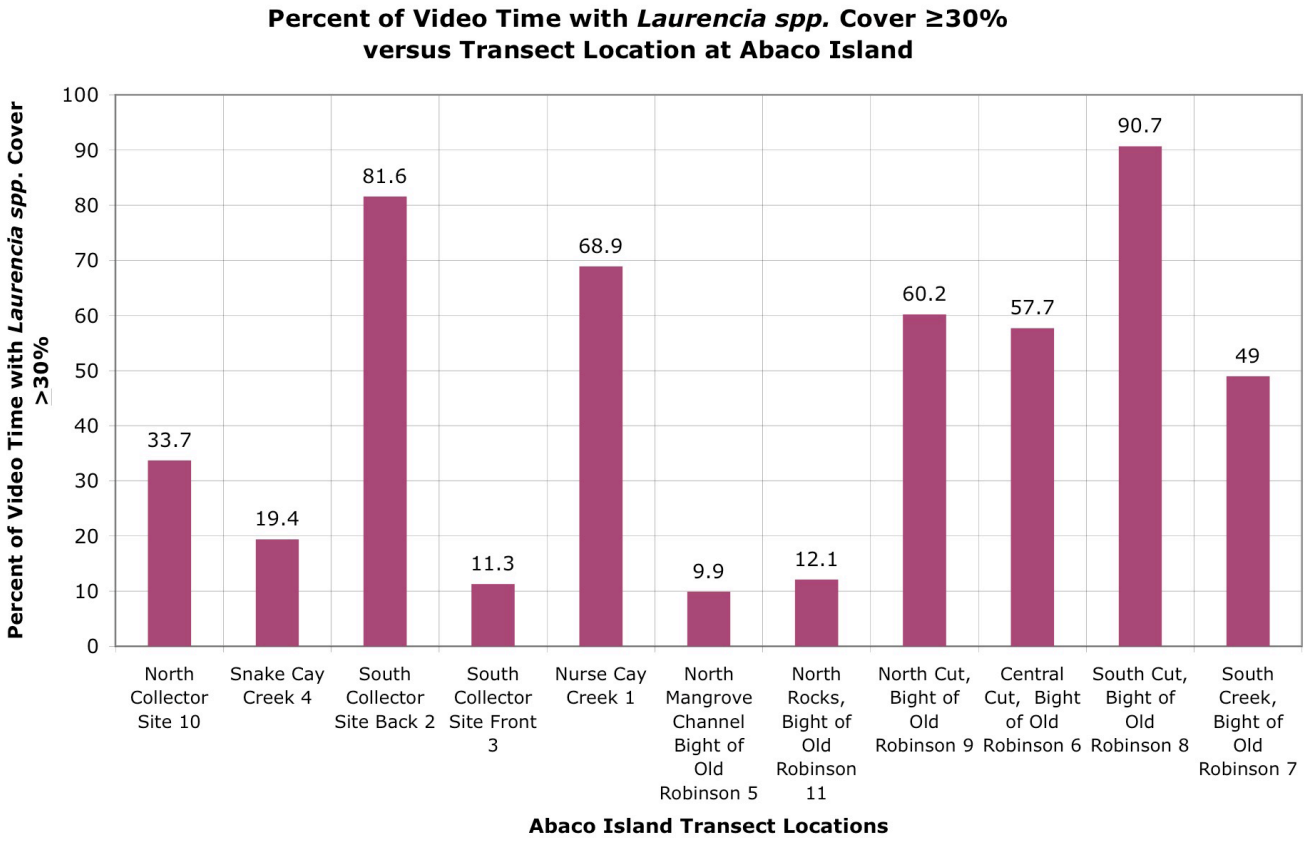
found at Transect 3, South Collector Site Front, at Abaco (75.9% of video time). At the Bight of Old Robinson, Abaco, seagrass cover increased from north to south around the bay (transects 5, 11, 9, 6, 8, 7). Blanket Sound, Transect 3, at Andros had the greatest seagrass cover (39.7%) of the eight Andros Island transects.

There were six habitat classification types that included *Laurencia spp*.; 1) sparse seagrass with *Laurencia*, 2) medium seagrass with *Laurencia*, 3) dense seagrass with *Laurencia*, 4) Batophora and *Laurencia* dominated, 5) *Laurencia* dominated, and 6) mixed macroalgae with no clear dominants but with significant *Laurencia*. For these six habitat types, *Laurencia spp*. percent cover ranged from 19% to 66% at Abaco and from 29% to 53% at Andros (see Figure 7).

Discussion

The Nassau grouper, Epinephelus striatus, represents one of the most important commercial fish in the Bahamas and neighboring oceans. Due to overfishing, the Nassau grouper is on the International Union of Conservation of Nature and Natural Resources red list of threatened species.[14] The Nassau grouper is a large top-level predator that can reach a meter in length and weigh 25 kg, and can significantly influence the structure of coral reef ecosystems.[15] The spiny lobster, Panuliris argus, also is a top predator that can greatly affect ecosystem composition. The spiny lobster can bring $60 million per year to the Bahamian fisheries industry.[1] Preservation of nursery habitats of both the Nassau grouper and spiny lobster represents an important component in the planning of marine protected areas.

Results here show that favorable nursery habitat exists at both Abaco and Andros Islands, based on Eggleston's[1] ≥30% *Laurencia spp*. cover figure as representing suitable



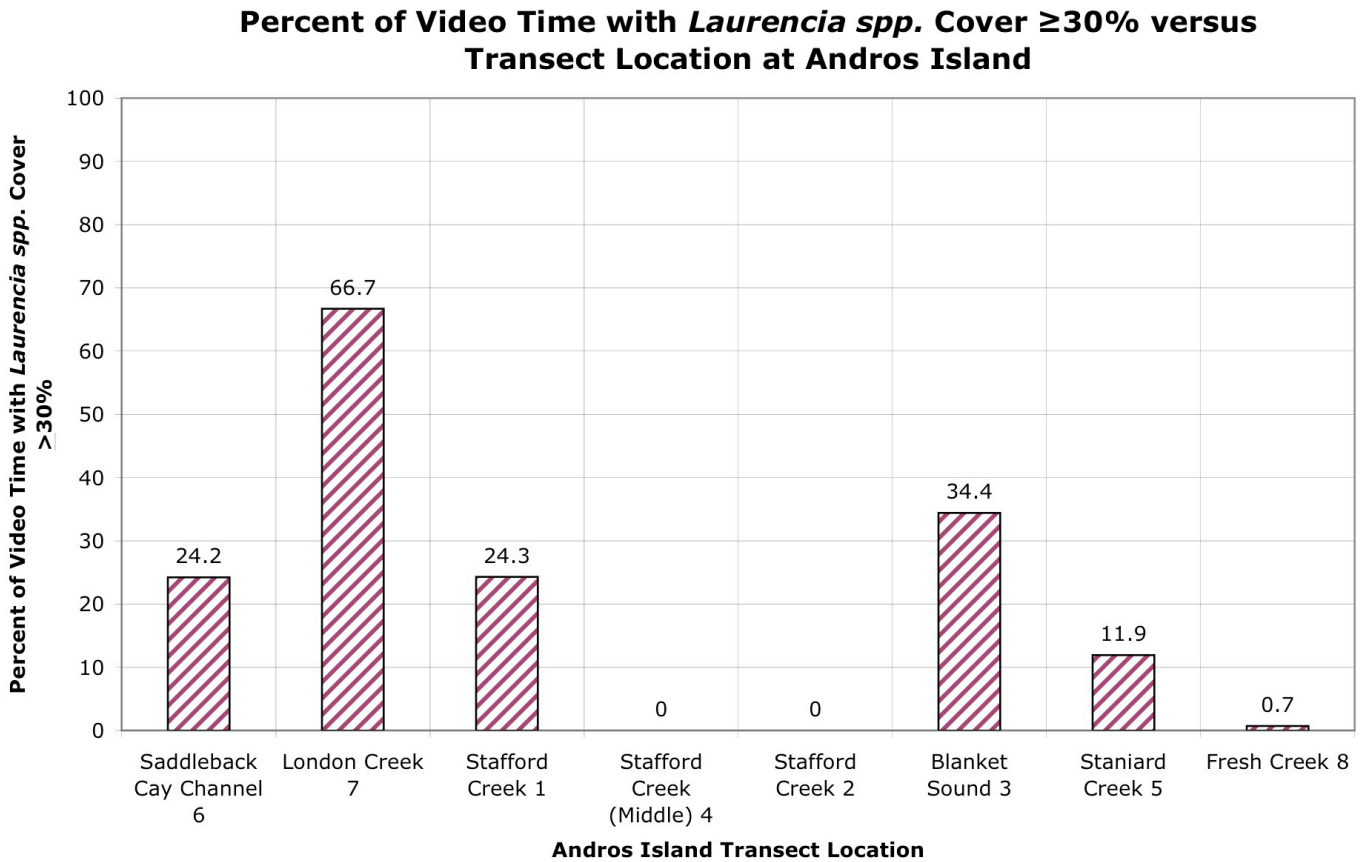
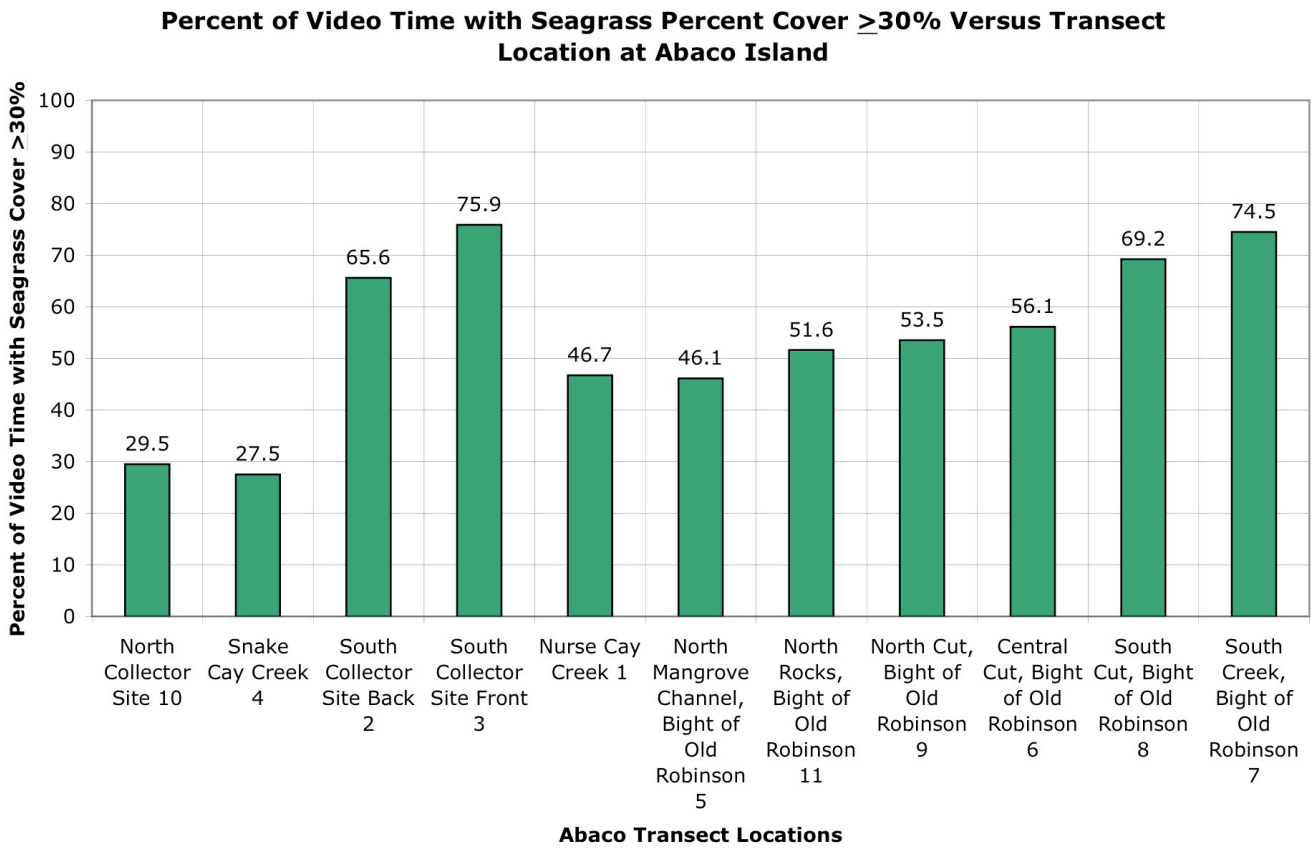


Figure 5: Percent of oblique video time with *Laurencia* spp. cover >30% at 11 transects at Abaco Island (top) and 8 transects at Andros Island (bottom).



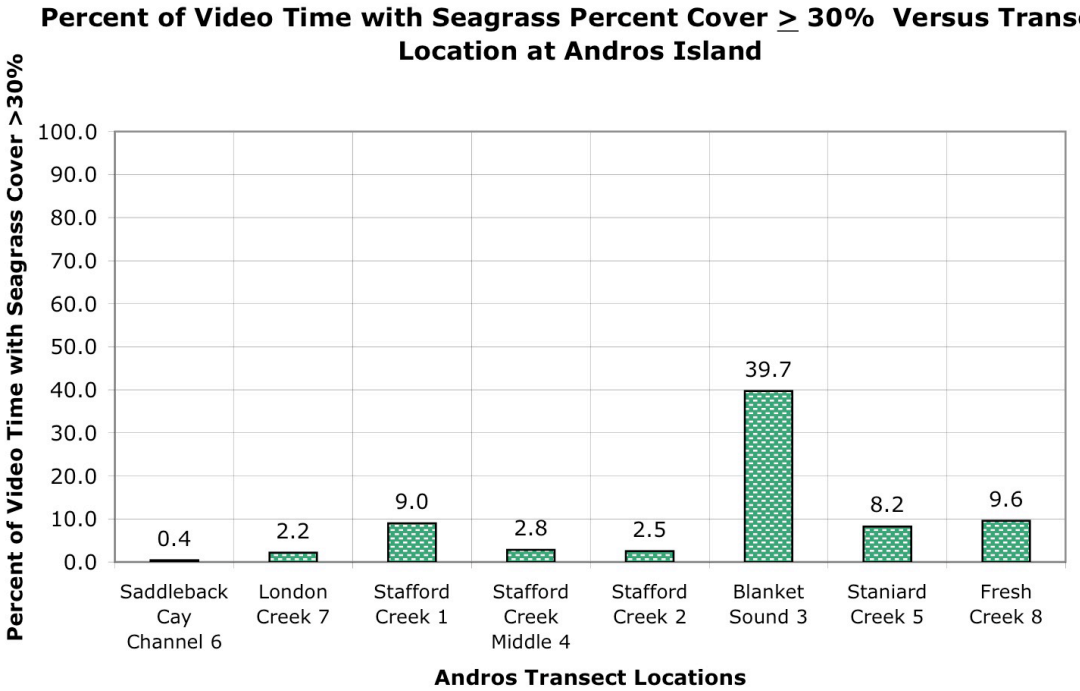


Figure 6: Percent of habitat classification video time with seagrass, Thalassia sp. cover >30% at 11 transects at Abaco Island (top) and 8 transects at Andros Island (bottom).

nursery habitat for Nassau grouper. There were both between-island and within-island variations in *Laurencia* cover. Habitat classification of video footage at eleven Abaco transects and eight Andros transects showed a greater percentage of video time with *Laurencia* cover at Abaco (median 49.0%) compared to Andros (18.1%). Individual transects varied in *Laurencia* cover from 0% (Andros Transect 2 and 4) to 90.7% (Abaco Transect 8).

While this report focuses on the occurrence of *Laurencia spp*. at study transects at Abaco and Andros Islands, the attention given in the literature to seagrass as a nursery

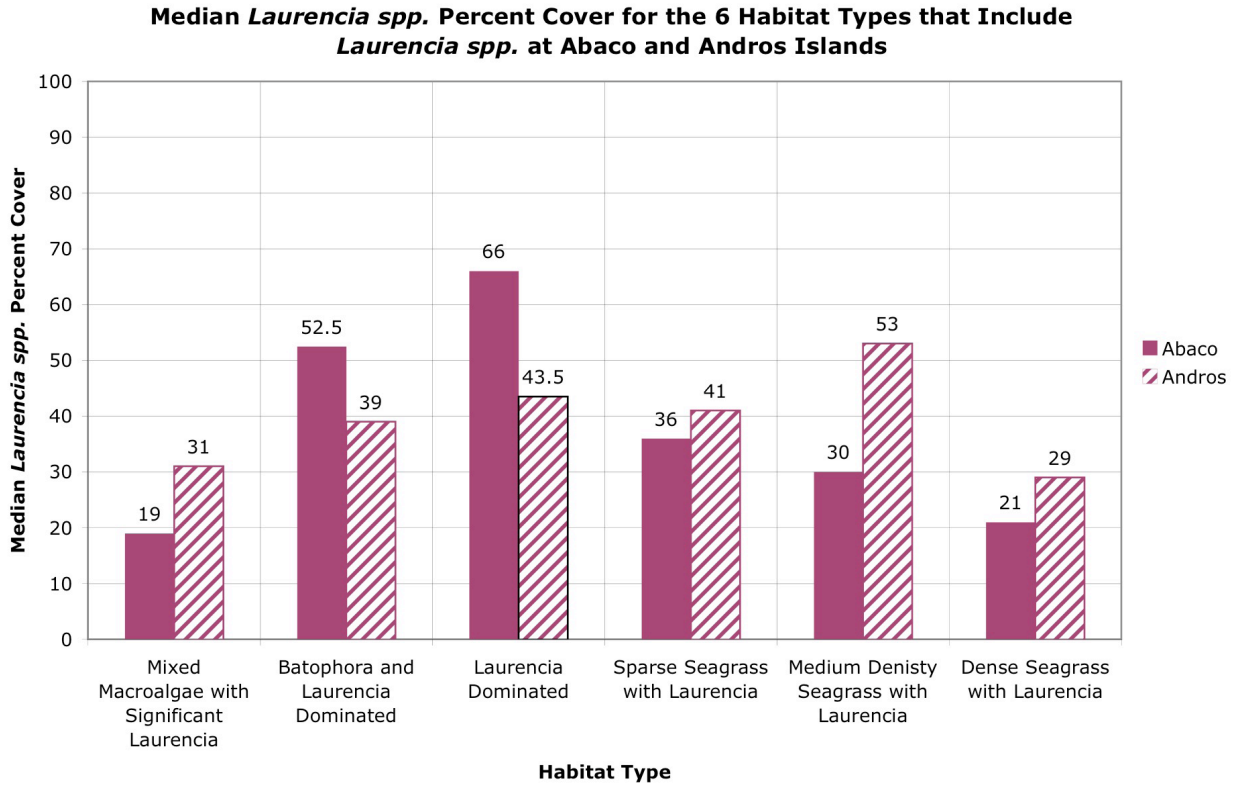


Figure 7: Median *Laurencia* spp. percent cover for the 6 habitat types that included *Laurencia* spp. at Abaco and Andros Islands.

site[2,7,8,9] prompted the inclusion of seagrass results here. Seagrass habitats were common, especially at Abaco. The percent of video time with ≥30% seagrass cover was notably higher at Abaco (median 53.5%) compared with Andros (5.5%), a factor that may be of potential value in the designation of protected areas.

Lipcius et al. report that suitable macroalgae nursery habitats are relatively rare in the Bahamas, and only a small percentage of settlement-stage individuals may end up in these habitats, thus creating spatial scale population bottlenecks.[16] This habitat scarcity increases the importance of protecting these crucial nursery habitats in marine protected areas. In the Florida Keys, Herrnkind et al. found that areas of *Laurencia spp*. that were heavily silted supported fewer spiny lobsters.[17] These authors note that human activities that produce silt, such as coastal development, channel construction, dredging, spoil dumping, and mining represent a serious threat to the spiny lobster. Butler et al. found that both the influx of spiny lobster postlarvae and macroalgal settlement habitats in Florida Bay varied independently and simultaneously over short time intervals.[8] Changing percent cover and patch size of macroalgae over time and space complicate the predictability of adult population sizes from postlarval supply, information that should be considered in selecting habitats for protection.

The transects studied here reflect only small portions of the eastern coast of Abaco and Andros Islands. Further studies are needed to explore benthic habitat elsewhere at these islands as well as at other locations in the Bahamas. The underwater photography technique that incorporated two video angles proved effective in determining habitat type and species cover. Additional studies should investigate whether young Nassau grouper and spiny lobster actually utilize the potential nursery habitats at Abaco and Andros Islands.

Conclusions

This research showed *Laurencia spp*. cover ≥30% at both Abaco and Andros Islands. Thus, both locations include potential nursery habitat for the Nassau grouper and spiny lobster. Transects at Abaco contained a greater percentage of video time with *Laurencia spp*. ≥30%. Video time with seagrass cover ≥30% also was much greater at Abaco. In terms of *Laurencia spp*. and seagrass habitat availability, Abaco Island especially merits inclusion in a marine protected area.

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in training and guiding me in my research. Dr. Brumbaugh provided survey films, and Dr. Eric Treml provided the transect maps. I am grateful to the American Museum of Natural History in New York and the National Science Foundation for funding my internship.

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Molecular and Morphological Characterization of Two Species of Sea Cucumber, Parastichopus parvimensis and Parastichopus californicus, in Monterey, CA

Christine O'Connell[1]

California is home to two species of commercially-fished sea cucumber, *Parastichopus parvimensis* and *Parastichopus californicus*. Appropriate management of their fisheries and of California's marine communities in general depends on a complete understanding of the differences between their populations. This study uses molecular and morphological techniques to more accurately define the differences between *P. parvimensis* and *P. californicus*. Genetic sequencing of the COI mitochondrial gene found an average pairwise diversity (pi) within each species (*P. parvimensis* pi of 0.0031 and *P. californicus* pi of 0.0039) that was an order of magnitude smaller than between the species (pi of 0.0560). Additionally, a survey of ossicle morphologies found observable differences between the ossicle types in each species that we successfully used to distinguish between *P. parvimensis* and *P. californicus*. Management strategists can use this refined knowledge in the future to target their marine policies.

Introduction

Parastichopus parvimensis and *P. californicus*, two ecologically-similar species of sea cucumber, are the only sea cucumber fisheries in California.[1] Aside from the economic importance that this distinction affords them, the two also play an important ecological role as subtidal, benthic detritivores.[1, 2] Though some ecological distinctions between the two species exist – *P. californicus*, notably, can be found at greater depths (to 150 m) than *P. parvimensis* (to 20 m) (A. Haupt personal communication) – the ostensible similarities between them raise questions concerning the dual management of their two fisheries[3]. Cursory phylogenetic surveys have shown the two to be closely related (4), but the genetic and morphological similarities between *P. parvimensis* and *P. californicus* have yet to be studied in depth.

Historically, sea cucumbers cucumber species' ossicle characteristics are used as distinguishing characteristics for taxonomic differentiation. Ossicles are calcareous structures embedded in sea cucumbers' body wall tissue.[2] They are the miniscule remnants of ancestral species' skeletal material. More importantly, each species has uniquely patterned ossicles, and it's these patterns that scientists have often used as key identifying features when defining sea cucumber taxonomy. In the case of the externally similar *P. parvimensis* and *P. californicus*, ossicle characterization becomes particularly important for species identification; ossicle descriptions have been published for *P. californicus* but have not yet been described for *P. parvimensis*.[2]

In this study I use molecular as well as the ossicle-based, traditional morphological techniques to investigate the delineation between *P. parvimensis* and *P. californicus*. Molecular techniques have outstripped morphological techniques in quantifying how distinct two species are, and can be used to investigate the extent to which two species share genes. This study supplements molecular with morphological techniques in order to establish a knowledge base concerning in what ways *P. parvimensis* and *P. californicus* differ: ossicle identification guides can provide a simple means of telling two ostensibly similar species apart.

California's sea cucumber fisheries have seen population effects due to fishing since the 1980s and their management is ongoing.[1,5] That management can be refined by garnering more sophisticated information about how and to what extent two species differ – in particular, biodiversity conservation strategy and marine reserve design both benefit from natural history studies.[6-13] Investigating species diversity contributes to the scientific knowledge base that policymakers and marine managers draw from.

Methods

Sample collection:

Tissue samples were collected using sustained underwater breathing apparatus (SCUBA) by removing a small spine from each cucumber with scissors. This sampling method is non lethal (previous experiment A. Haupt) but also leaves each cucumber with a scar to prevent taking repeated samples from the same individual. These samples were then placed in 95% ethanol and taken to the laboratory for molecular analysis.

Forty-two samples of *P.*

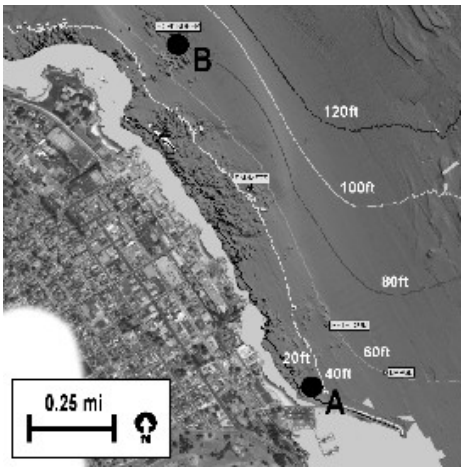


Figure 1: Map of South Monterey . Point A indicates the San Carlos Beach collection site; point B indicates the Hopkins Deep Reef collection site.

[1]Stanford University

parvimensis were collected haphazardly at San Carlos Beach between two and twelve meters depth. Fifty-seven samples of *P. californicus* were collected at Hopkins Deep Reef between 20 and 23 meters depth (fig. 1).

Molecular Analysis:

Molecular analyses were used to determine genetic complexity both within a single species (i.e. across individuals) and among species – in this case, using sequences of the mitochondrial DNA (mtDNA) cytochrome oxydase subunit I (COI) gene for both *P. parvimensis* and *P. californicus*. DNA was extracted from each sample using a NucleoSpin DNA extraction kit (BD Biosciences, San Jose, CA). The mitochondrial gene COI was amplified by polymerase chain reaction using the following primers: COI ef (ATA ATG ATA GGA GGR TTT GG) and COI er (GCT CGT GTR TCT ACR TCC AT) (4) and a FermentusTaq PCR Master Mix (Applied Biosystems). The PCR profile consisted of: 94°C(120sec), 35x(94°C(45sec), 49°C(45sec), 72°C(90sec)). Gel electrophoresis was used to confirm amplification. Amplification products were cleaned using a SAP-EXO reaction (USB Corporation, Cleveland, Ohio) according to manufacturer's instructions. Cycle sequencing was conducted with both amplification primers and BigDye Terminator v3.1 (Applied Biosystems, Inc., Foster City, California). Fluorescently-labeled products were then precipitated using isopropanol. Chromatograms of these samples were produced by an ABI 3100 sequencing machine (Applied Biosystems, Inc., Foster City, California).

The raw sequences were aligned and edited using the program Sequencher version 4.5 (Gene Codes Corporation, Ann Arbor, Michigan). PAUP was used to calculate pairwise difference for all samples. F-statistics (FST values) were calculated using Arelquin.

Morphological comparison:

In order to extract a collection of ossicles, small tissue samples from each individual were submerged in household bleach in vials and left to dissolve. After approximately twenty minutes, or when the tissue was visibly dissolved, vials were centrifuged for three minutes. The bleach was then siphoned off and replaced with water, after which the vials were centrifuged a second time and the liquid was once again siphoned and replaced with fresh water. Vials were then agitated to resuspend the ossicles. Finally, the sample was pipeted onto a microscope slide and placed under an optical microscope. Representative digital photographs were taken of the various ossicle morphologies.

Results

Molecular Analysis:

Both molecular and morphological analyses showed consistent polymorphisms between *P. parvimensis* and *P. californicus*.

Wright's F statistics (14) were calculated using Arlequin to calculate an Analysis of Molecular Variance (AMOVA) as a measure of the genetic differences between sample populations. FST values range from 0.0 to 1.0, with 0.0 indicating that there is as much variation within a species as between the species. The FST between *P. parvimensis* and *P. californicus* was 0.93756 (P <0.0001).

Pairwise diversity (pi) indices further support the observed population differentiation. Table 1 reports the average, maximum and minimum pi values seen between pairings of individuals from a single species and also between pairings of individuals from both species.

Pi is a quantification of the genetic differences between each pair of samples in a group of individuals. In contrast to this pairwise comparison, FST compares the aggregate variation within groups (in this case, within species) with the aggregate variation between groups.

In addition to that between species, genetic diversity was observed within the species. *P. parvimensis* had 13 distinct haplotypes and 16 polymorphic sites in 42 samples. *P. californicus* had 24 distinct haplotypes and 30 polymorphic sites in 57 samples.

Species	Samples	Average Pi	Maximum Pi	Minimum Pi
P. parvimensis	41	0.003162528	0.00946733	0
P. californicus	68	0.003997606	0.01869159	0
All samples	109	0.05600522	0.0635514	0.05233645

Table 1: Pairwise distances between and among *P. parvimensis* and *P. californicus*

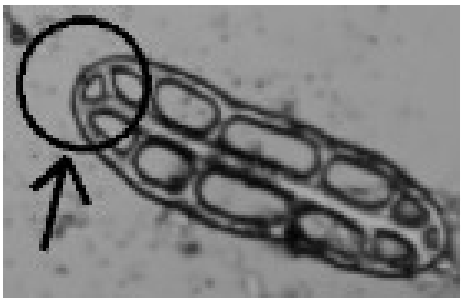


Figure 2: *P. californicus* ossicle.

Morphological comparison:

Ossicle morphologies were compared in a random sample of individuals from each species to create guidelines for species identification. Two separate researchers then used these guidelines to attempt and identify ten samples' species identity (known

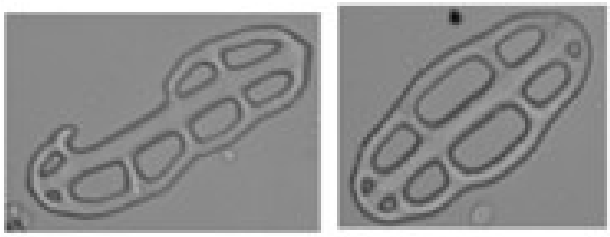
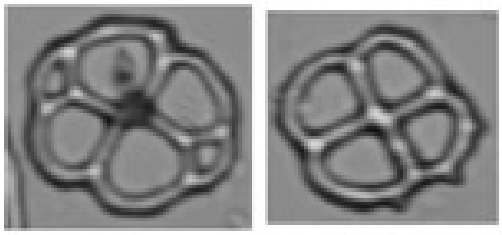
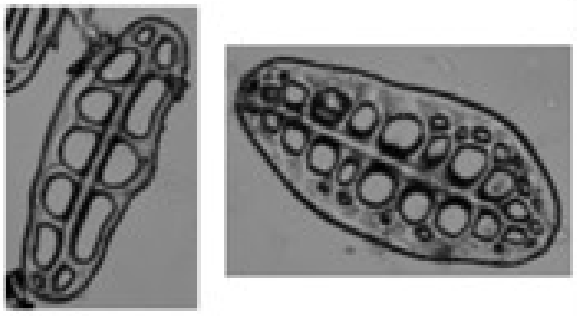
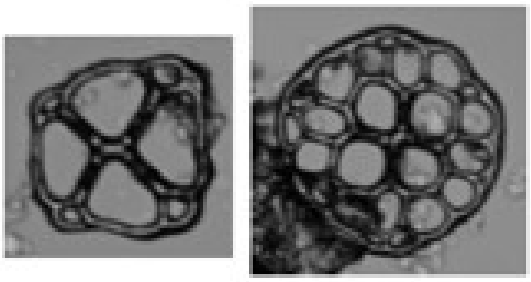
Species	Oblong	Circular
P. parvimensis		
P. californicus		

Table 2: Oblong and circular ossicle details

from earlier genetic sequencing); in both tests 100% of the identifications were correct.

Both species were observed to have two primary ossicle morphologies, oblong and circular. Table 2 illustrates the morphology details.

P. parvimensis, as a generalization, has less intricate ossicles than *P. californicus*. *P. parvimensis*' oblong ossicles tend to have fewer holes than those of *P. californicus*; the somewhat deformed oblong ossicles (R, *P. californicus* oblong picture) were exclusively seen in *P. californicus* samples. Finally, *P. californicus* oblong ossicles are more likely than *P. parvimensis* ossicles to have triangle holes at each end (fig. 2).

The circular ossicles feature a similar pattern: *P. californicus* circular ossicles are more likely to have small holes at the ends of the diameter axes (L, *P. californicus* circular picture). Like the deformed oblong ossicles, the particularly complex circular morphology (R, *P. californicus* circular picture) were only observed in *P. californicus* tissue.

Perhaps most definitively, the two species' ossicles differ markedly in size (fig. 3). *P. californicus*' ossicles are consistently 40-60% larger than *P. parvimensis*'.

Discussion and Conclusions

Morphologic and genetic comparisons are consistent in finding distinct and measurable differences between *P. californicus* and *P. parvimensis*. The maximum pairwise diversity within both *P. parvimensis* and *P. californicus* (0.0095 and 0.0187 respectively) is substantially smaller than even the minimum pairwise diversity observed in the group of samples that contains both species' individuals (0.0523). In other words,

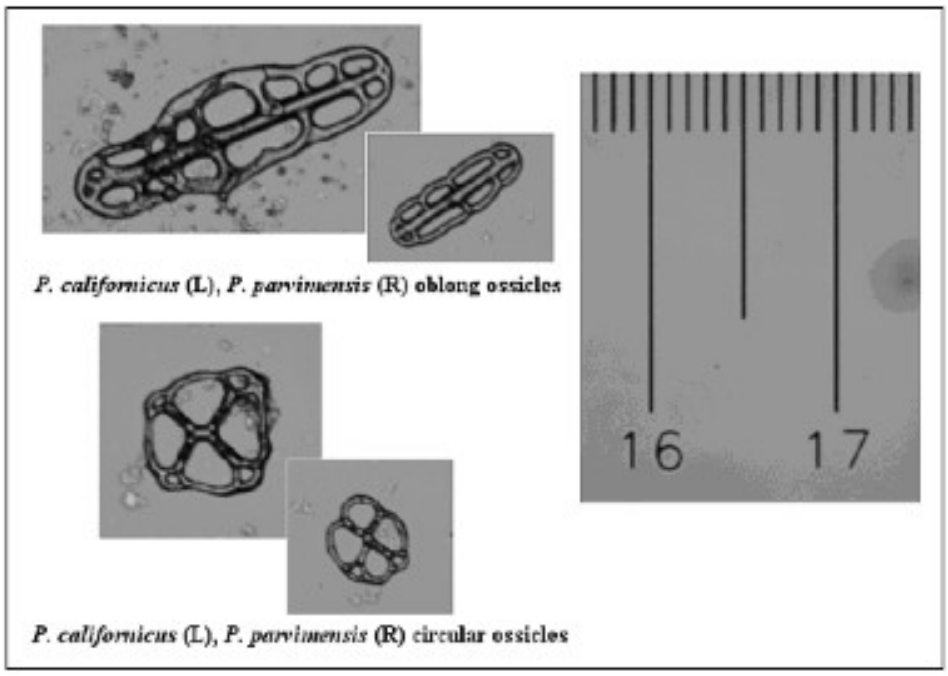


Figure 3: Size differential between *P. californicus* and *P. parvimensis* ossicles

pi results show that there are more substantial differences between the individuals of both species than between the individuals of either species alone. These results are supported in the aggregate by the statistically significant high Fst of 0.93756 ($p < 0.001$).

Molecularly, then, *P. californicus* and *P. parvimensis* are genetically distinct. Furthermore, a comparison of the two species found that their ossicles were visually distinct: both the size and shape differences allowed technicians to accurately discriminate between the two species. Ossicle comparison is routinely used to distinguish between sea cucumber species; these morphological results contribute to the natural history information available for these two species.

Marine management strategies aimed at protection of biodiversity should continue to value *P. californicus* and *P. parvimensis* as distinct species that contribute independently to marine communities' biodiversity. Future fisheries sustainability studies can build on these results to further define how conservation efforts can take Californian community diversity into account.

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Functional Imaging of Zebrafish Visual Processing Following Tricaine Anesthesia

Alyssa Tonelli[1]

Zebrafish are highly visual animals. The goal of these experiments was to compare how adult zebrafish and zebrafish larvae respond to light pulses. The zebrafish were anesthetized with tricaine, injected with calcium indicators, and imaged with a two-photon microscope. Developing the optimal anesthetization methods was essential to ensure the survival of the zebrafish and avoid adverse affects to their visual system. Using two-photon microscopy, calcium dynamics were observed in individual neurons in response to computer programmed light pulses. The light pulses were given at different intervals for the adult zebrafish and the zebrafish larvae. Each fish's response contributed to the investigation of the visual signals in the optic tectum, which is a complex layered structure in the brain. Exploring the cognitive function of both adult and larval zebrafish using two-photon microscopy has never been done before and provides greater insight into the neural processing and development of the zebrafish brain.

Introduction

Zebrafish are highly visual animals and process visual stimuli through neurons in the optic tectum. The optic tectum in an adult zebrafish is a seven-layered structure that contains the highest concentration of visual inputs, approximately one to two millions neurons. The layers of the optic tectum begin with the most superficial layer, 7, progress deeper into the tectum through layers 6, 5/6, 4/5, 4, 3/4, 3, 2/3, 2, and end with layer 1.[1] Layer 7 receives information from the retina and layer 1 is the deepest layer where many cell bodies are located; indeed, a large concentration of neurons that respond to visual stimuli, called type XIV neurons, have cell bodies implanted in layer 1.[2] In zebrafish larvae there are only two layers in the optic tectum, rather than seven.

Many scientists have studied how zebrafish process visual stimuli through a variety of means, particularly electrophysiology. Previous studies have attempted to explain how the adult zebrafish and larvae respond to visual stimuli and have provided insight into the morphology of the retinotectal processes of the optic tectum, [2] but no studies have used two-photon microscopy to investigate responses to light in a living adult zebrafish injected with calcium indicators.[3] In this research project, we used two-photon microscopy to explore the visual system of adult and larval zebrafish and their responses to visual stimuli. Two-photon microscopy was best suited for this experiment because its high resolution and exquisite detail in deep tissue imaging makes it more advantageous than other types of microscopy. Two-photon microscopes provide sharp images in scattering tissue because two photons, rather than one, are needed to excite the dye.[4] As a result, the images are clearer and more precise, with decreased photo-bleaching, making this form of microscopy ideal for the imaging of zebrafish.

Few studies have used tricaine to anesthetize zebrafish before imaging them with the two-photon microscope and recording the effects. Tricaine can cause blindness at high concentrations, but is an effective anesthetic. Hence it was important to investigate whether or not tricaine affects the visual behavior of adult zebrafish. Because tricaine affects the zebrafish visual system, it must be appropriately regulated in order to accurately study the response of the zebrafish optic tectum to light pulses. This experiment offers a new approach for studying adult neural circuitry and how zebrafish develop using tricaine.

Material and Methods

Zebrafish larvae were anesthetized with a few drops of tricaine stock solution in their water. Then they were immobilized in agar, injected with Oregon Green Bapta 1 AM 488 (OGB-1) and imaged with a two-photon microscope.[5] The group of zebrafish larva did not require curare which immobilizes the fish for surgery. Following anesthesia, microsurgery, and microinjection, the adult zebrafish were imaged with a two-photon microscope.

Anesthesia and Immobilization

In order to anesthetize and immobilize a zebrafish before surgery, the gills were perfused with 0.6mM tricaine for three minutes so that the

fish	onset time (seconds)
a	170
b	90
c	150
d	130
e	60
f	140
g	60
h	90
i	140
j	180
k	240
l	170
m	171
n	48
o	120
mean onset time (seconds)	standard deviation (seconds)
130	50

Table 1: Onset Time of Anesthesia (0.6mM Tricaine). The duration of 0.6mM tricaine anesthetic in adult zebrafish. The average onset of anesthesia in which there was no movement or response to mechanical stimuli was 2 minutes 10s with a standard deviation of 50s. However, the onset times ranged from 48s to 4 minutes.

[1]Stanford University

zebrafish would remain unconscious during the surgery and were then paralyzed with curare. Afterward, its gills were perfused with 80% HANKS so it would be neurally active. A recipe for tricaine was found at ZFIN[6].

To determine whether tricaine adversely affected adult zebrafish's visual behavior, the following was done. One zebrafish was kept in the dark and another zebrafish in a well-lit room to determine if light exposure affected its response to light flashes. As a control, one zebrafish without tricaine was placed in the dark and another zebrafish without tricaine in the light. The tricaine zebrafish in the light died of the anesthetic. The light zebrafish without tricaine was placed in front of a white screen for five minutes and both dark zebrafish were placed in front of a black screen to allow them to habituate to their new surroundings before triggering the looming stimulus. The looming stimulus was triggered for each zebrafish before the experimental group was anesthetized and after they recovered. Zebrafish were stimulated about every 30 minutes for 1.5 hours.

Surgery

In the surgery, a small portion of the cranium was removed with sharpened titanium forceps, opening a window into the optic tectum. The tectum's location was determined by reviewing images such as dorsal views and coronal cross sections of the adult zebrafish brain.[7]

Injection

Calcium indicators were microinjected into the optic tectum with a micropipette using pressure pulses. OGB-1 was injected and Calcium Green-1 Dextran (10,000 kD) (CGD-1) was electroporated into the cells. OGB-1 was made using the process described in Brustein et al (2003).[8] Two calcium indicators were used to stain neurons in the optic tectum and view these neurons using a two-photon microscope: OGB-1 and CGD-1 Both types of dye have been used in zebrafish, but rarely in conjunction with two-photon microscopy.

Imaging

After injection, zebrafish were imaged with an Olympus two-photon microscope. The zebrafish were stimulated with a computer controlled light source. Light flashes were directed to the contralateral cornea by a fiber optic using a code written in Python (Anderson K, personal communication, April-June 15, 2007). The program triggers lights and scans and is important because it prevents the light from interrupting the scans. The zebrafish were imaged using two-photon microscopy employing a coherent optics TiS laser and Olympus Fluoview software. Images were post-processed using Image-J and IGORE (Wavemetrics, Inc.).

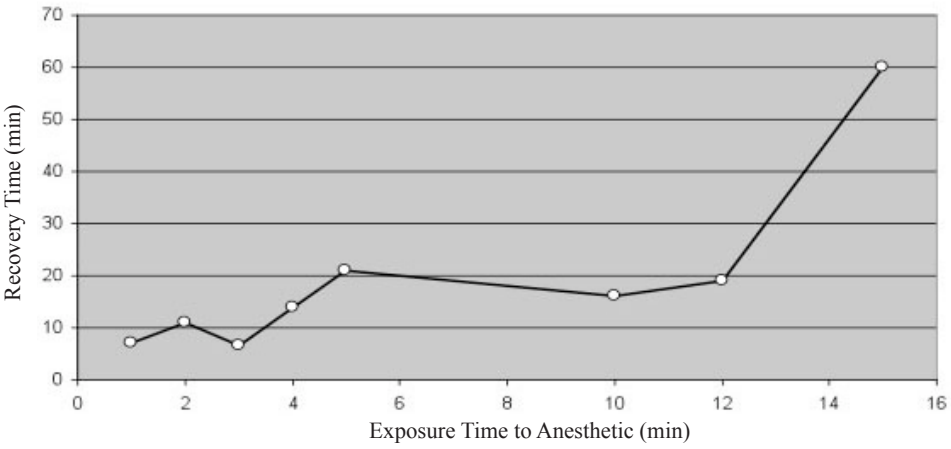

Figure 1: Adult Zebrafish responses to 0.6mM Tricaine for Various Time Periods. A dose-response curve was created by anesthetizing adult zebrafish with 0.6mM tricaine for 1 minute to 15 minutes. How long it took for the zebrafish to recover from tricaine after each exposure was recorded. The end of the recovery time was defined as the time that the fish began to swim upright. The goal was to determine the appropriate exposure of tricaine for a given surgery time.

Results

The adult zebrafish were quite variable in their responses to tricaine. One zebrafish required only 48 seconds to become fully anesthetized while another required a four minute exposure time (Table 1). Some zebrafish immediately decreased their swim speed and turned upside down before becoming completely anesthetized, while others swam normally and even responded to mechanical stimuli normally for several minutes.

A critical part of the procedure was the anesthesia. The recovery time from tricaine was determined for an adult zebrafish by creating a dose response curve. The longer the zebrafish were under the influence of tricaine, the longer it took for the effects of the anesthesia to subside once the tricaine was removed. However, it took ten to fifteen additional minutes until the fish swam upright and responded to mechanical stimuli as it did before anesthetization. The mechanical stimulus was a pair of forceps tapping the zebrafish's side. The dose-response curve enabled the determination of the correct amount of time the fish should be anesthetized while performing microsurgery.

The zebrafish were anesthetized for three minutes so there would be ten minutes to do the surgery. The reason why the recovery time for the zebrafish at five minutes was greater than the recovery time at ten minute and twelve minutes may be because the same fish was tested twice, once at three minutes and then at five minutes (thus receiving a higher dose of tricaine than the other fish) (Figure 1). The zebrafishes' responses to tricaine varied. One example of how

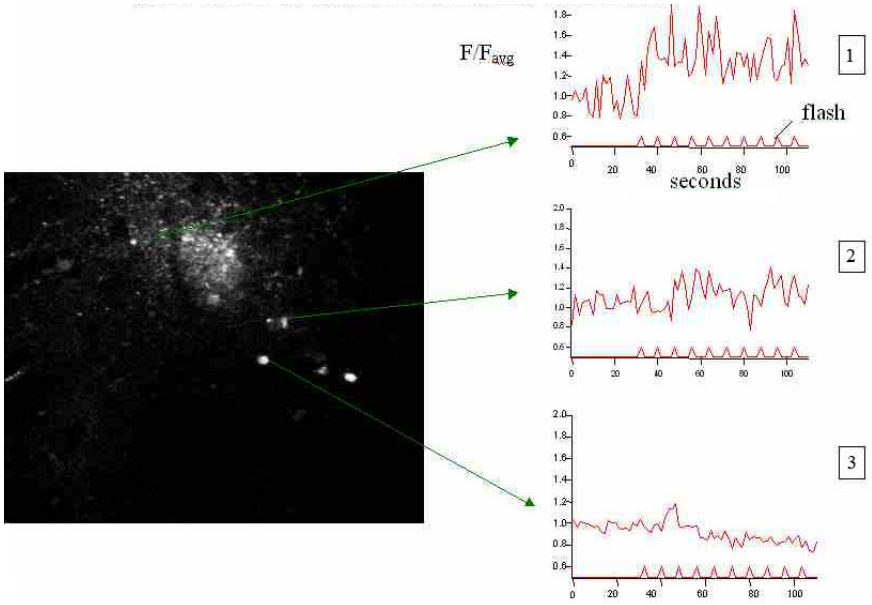

Figure 2: Three Neurons' Responses to Light Stimuli in an Adult Zebrafish. One second flashes were delivered to the contralateral eye at intervals of 10 sec. This image was stained with CGD-1. The top line of each graph is neuronal activity and the bottom line of each graph is the light flash sequence after a 30s baseline period. F/Faverage is the fluorescence at the neuron of interest divided by the average fluorescence from all of the pixels in the image. An increase in fluorescence indicates an increase in calcium.

zebrafish responses to tricaine varied is that one zebrafish remained in 0.6mM of tricaine for approximately three minutes and responded completely normally after seven minutes while another zebrafish placed in tricaine for the same amount of time and did not wake up. Variations in recovery time during the first three minutes in the dose response curve were also probably due to the individuality of the zebrafish (Figure 1).

Responses to the looming stimulus showed that tricaine does not adversely affect zebrafish visual behavior. All three zebrafish responded similarly to the looming stimulus before and after the anesthesia.

Calcium Green-1 Dextran (10,000 kD) Dye Stains Selectively

CGD-1 stains selectively creating a greater distinction between different neural processes. One cell body is 10.0 µm. Cell bodies are approximately10 µm.

Adult Zebrafish and Zebrafish Larvae Responses to Two-Photon Microscopy Light Stimuli

I observed how closely correlated neuronal activity was to the emission of each the programmed light pulses. Each response by the three neurons labeled above was different. $F/F_{average}$ is equivalent to the value of fluorescence for a given cell each second divided by the baseline. The baseline is the average of all of the pixels during the first 30 frames when there was no flash. $F/F_{average}$ is not the same for each neuron, indicating variations in activity. In Graph 1, there is an increase in calcium after the first flash that persists throughout the entire sequence and reflects an increase in activity (Figure 2). Graph 2 shows a neuron whose calcium levels increase later, on the third flash, and the activity remains high (Figure 2). The activity in the tectum does not correlate with every flash. Rather, there is an overall increase in fluorescence during the entire series of flashes. Graph 3 shows a neuron that fires at the third flash, but has even less calcium than the baseline afterward, probably due to inhibition (Figure 2).

Calcium levels increased when the flashes started and remained high throughout the entire 46 seconds (Figure 3). The greatest amount of activity was at 11s and at 16s. Both neurons had the greatest amount of activity during the first two flashes (11s and 16s) and maintained high calcium levels (Figure 3). One neuron responded to every light flash and the other responded less regularly. The zebrafish larva responded to light flashes more regularly than the adult zebrafish. Like the adult zebrafish, the calcium levels increased in the two cells, starting on the first flash and continuing through the final flash (Figure 3).

Discussion

OGB-1 is a cell permeable dye that is taken up by all cells in the tectum. In contrast, CGD-1 is taken up by cells through electroporation or by access through a damaged membrane. CGD-1 is more selective than OGB-1, stains fewer neural processes, and as a result, there is a greater distinction between different neurons and extracellular space.[8] Although OGB-1 worked well when staining zebrafish larvae, the CGD-1 provided better stains in adults (Figure 2).

Individual zebrafish responses to the looming stimulus before and after tricaine were observed. The adult zebrafish under the influence of tricaine responded comparatively to the looming stimulus before and after the anesthesia. The same was true for the two control zebrafish that were not exposed to tricaine.

Although the light fish died of the anesthetic, the other three fish were in the tricaine for a similar amount of time and recovered in seven minutes, as expected (Table 1). The inability of the light zebrafish to cope with the same dosage as the average anesthetized zebrafish, is a primary example of the variability in behavior between zebrafish in response to tricaine. Adult zebrafish responses with respect to the onset time of the tricaine as well

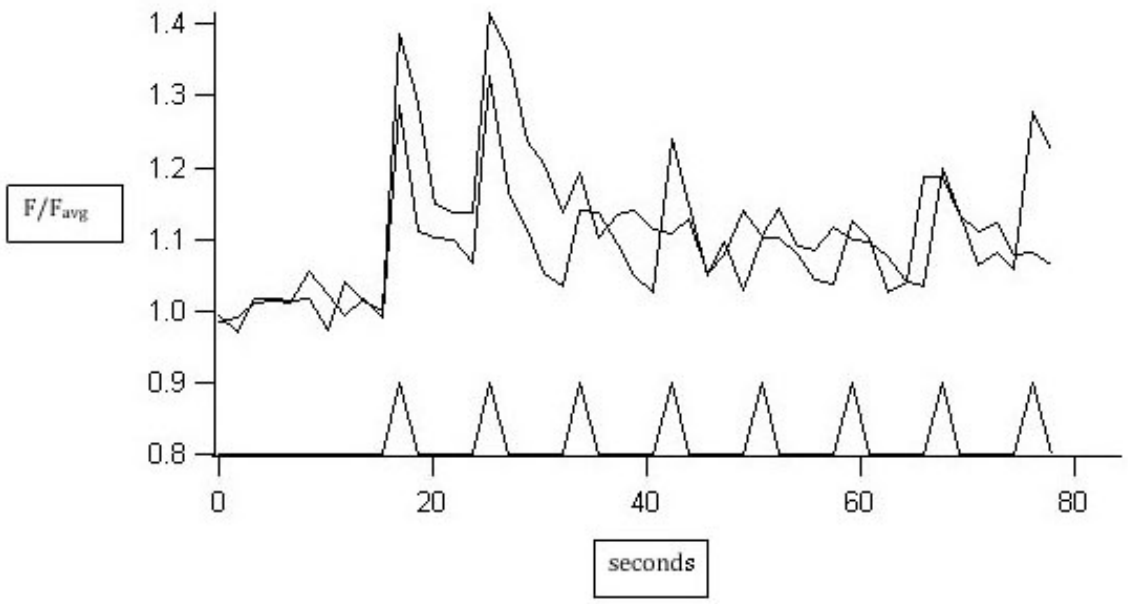

Figure 3: Two Neurons' Responses to Light Stimuli in a Zebrafish Larva. An example of how two neurons in a zebrafish larva respond to light pulses. A zebrafish larva was stimulated with sequenced light pulses every 5s starting at 11s and ending at 46s. OGB-1 was used to create this image. The image was taken 21um deep in the tectum. Flashes are 2s long.

as the length of time they are exposed to tricaine were unique to individual zebrafish (Table 1).

The most effective length of time to anesthetize adult zebrafish is three minutes using 0.6mM tricaine for a ten-minute surgery. The tricaine did not adversely affect larval or adult zebrafish visual behavior. The standard deviation of 50 seconds for the onset of tricaine is large, supporting that there is substantial variability in behavior between zebrafish They reacted uniquely to tricaine, the looming stimulus, and the light flashes. As a result, it was difficult to understand general behavior trends that apply to all zebrafish or even all adult zebrafish. In adult fish, recovery times ranged from 48 seconds to four minutes. In response to the looming stimulus, some fish ceased to swim, others splashed wildly against the beaker, while many others reacted in between these two extremes. There was a diversity of responses to light as well. Some fish experienced high levels of activity while others did not react at all. Layers in zebrafish larvae are not as deep as those in adult zebrafish and as a result it is easier to observe a higher concentration of neurons. However, not all zebrafish larvae responses were identical and even neurons in the same zebrafish responded differently.

Conclusion

By studying how adult zebrafish and zebrafish larvae react to sequenced light pulses using tricaine anesthetization techniques and two-photon microscopy, three main conclusions were attained. First, the ideal time period to anesthetize adult zebrafish is three minutes using 0.6mM tricaine. Second, images of adult and larval zebrafish using the above methods clearly depicted layers, cell bodies, and neural processes. Third, the adult zebrafish and zebrafish larvae increased activity during the light flashes, but the responses were complex and irregular. It is important to continue to study these animals and learn more about their visual behavior in order to increase our understanding of visual processing.

Experiments that could build upon this work could test adult zebrafishes' response to a looming stimulus, which simulates the attack of a predator, rather than light pluses. The duration of the stimulus, interval between stimuli, and how many times the stimulus is repeated could be investigated. Another interesting experiment would be to determine how many repetitions of the looming stimulus and at what intervals the stimulus should be given in order for the zebrafish to become habituated to the stimulus. These results could then be compared to the same experiments in zebrafish larvae. On the cellular level, a dye that only stains cell bodies could be created and so the cell bodies would be easier to monitor and distinguish from other neural entities including fat and skin. These experiments will give more insight into the visual processing of adult zebrafish and zebrafish larvae; as a result, more knowledge can be contributed to the field.

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visual system. In addition, Pricket and especially Anderson contributed to the Python program.

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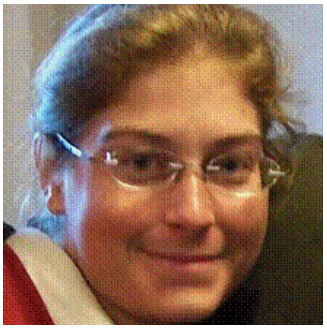

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Justifiers of the British Opium Trade: Arguments by Parliament, Traders, and the Times Leading Up to the Opium War

Christine Su[1]

In the events leading up to the Opium War, bilateral sovereignty and diplomacy were flouted in favor of British economic imperialism. Using sources from the British Parliament, London Times, and Canton opium traders to explain arguments from both the justifiers and the opposition to the smuggling trade in the years leading up to 1840, this paper examines the relevance of imperial prestige and ethnocentricity in political debates over British foreign policy in the mid-nineteenth century.

War in Defense of Drugs

Unlawful smuggling of opium had been taking place in Chinese ports for over a century when Commissioner Lin Zexu was appointed in 1839 to eradicate the opium trade in Canton, but official tensions between the Qing government and British representatives escalated soon after Lin demonstrated serious intent to fulfill his official duties. Following several unsuccessful edicts to ban the imports 1839, Lin blockaded the Canton port, keeping foreign merchants under house arrest until they surrendered their chests of opium for destruction. British forces, directed by Foreign Secretary Lord Palmerston, responded by sending a military expedition to Canton demanding reparations for the insult to British honor and £2 million loss of property in opium chests. These events set off the first Opium War in 1840.

What were the justifications used by officials and merchants for the opium trade in China, and how did they grapple with the moral implications of declaring war to defend illicit sales of an poisonous drug in a country which forbade its importation? Members of the British Parliament, the East India Company, and British merchants who traded opium in Chinese ports were all complicit in the sale of an addictive substance, in defiance of the Qing's efforts to stop it. How did these groups justify their roles in the opium trade, and what did these reasons show about imperialist tendencies towards China in the nineteenth century?

This paper will first outline a short history of the events leading up to the 1840 military expedition, looking at primary sources from top officials and merchants involved in the dispute. It will then examine the arguments in support of the expedition, given by British traders in Canton and the Indian opium merchants who supplied their cargo. Next, it will analyze the coverage of these issues in the London *Times* throughout this period. The *Times* was by far the most widely read newspaper in the 1840s, with a circulation of 38,100 (its five major rivals only reached a combined total of 18,000).[1] Finally, it will summarize Parliament's debates on the war with China, which took place in April of 1840. This exploration of the trade incentives, public news coverage, and government justifications of the opium trade will provide several insights on the British Empire's attitudes and approaches to economic imperialism in overseas trade.

To summarize briefly, the justifications for military action in response to Lin's destruction of opium chests fall under several broad categories:

1. Laws of the Free Market: The Chinese wanted to buy the opium anyway, so the British could not be held morally accountable for responding to consumer demand. Even if they sanctioned themselves, the Chinese would not stop purchasing opium, and other foreign merchants would take their profits.

2. Government-Sanctioned Property Rights: Opium merchants had operated under the unofficial approval of the British government for decades without sanction, and could not be reasonably expected to assume anything other than full protection of their cargo as property. They demanded payment for their lost cargo, either from the Treasury or by force from the Qing government.

3. Threat of Economic Upheaval: Opium was one of the most lucrative exports in the British trading empire, and India depended on supplying opium to Canton merchants to sustain its economy. A ban on opium would cripple Indian trade and dry up a crucial source of colonial revenue, imposing a heavy Treasury or taxpayer burden on Britain to support India's economic stability.

4. British Honor and Prestige: The ignominy of British citizens having to suffer deprivation of their liberties under Lin's house arrest incensed many Englishmen. Restoring the prestige of the Crown in Canton, as well as redressing the insults suffered by British traders, were the primary reasons Palmerston used to justify the expedition.

5. Arrogance of the Chinese: Numerous British accounts of Lin and the Qing government expressed dissatisfaction at the conceited and overbearing rhetoric in Lin's edicts and letters, which treated Britain as an inferior power and did not pay

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> full tribute to the British Crown's supremacy in the global order. Many merchants called on Britain to demonstrate its naval power in full force, teaching the 'barbarians' a lesson and dispelling Chinese notions of racial superiority.[2]

Subsequent sections will highlight these elements while studying the various source sets of merchant correspondence, public news, and Parliamentary debate. The next section will briefly sketch the history of official escalation leading up to Britain's military expedition to Canton.

History and Pre-1840 Imperialist Attitudes

In the decade before the war, the British sent high-ranking diplomats such as Lord Napier as envoys to negotiate around the unfavorable Canton Trade laws and "open up" Chinese ports to British trade. From 1834 onwards, the Qing government itself debated the legalization of opium, but ultimately decided against it and appointed Commissioner Lin Zexu to eliminate the trade in China completely. Lin's diplomatic counterpart was Charles Elliot, British Chief Superintendent of Trade in China, who became involved in extraterritoriality disputes and ultimately banned all trade with Guangzhou in 1839—the final escalation before the war.

In 1837, the Qing Emperor issued several commands to Superintendent Elliot to stop the opium traffic and remove ships which stored contraband cargo.[3] Elliot claimed that he had neither the authority to stop opium traffic from non-British ships, nor the means to regulate smugglers in addition to his oversight of regular trade.[4] Commissioner Lin Zexu was appointed in 1839—a vigorous administrator with a strict reputation against corruption.[5] He was determined from the beginning to stamp out opium trade, and saw Canton as a "complete cesspool of corruption."[6] Lin acted decisively—within three days of giving notice by official edict, he shut down trade in Canton, closed the customs office and walled the foreign traders in the port's factories until they surrendered all their opium cargo. Under pressure from the surrounding military forces, Elliot capitulated and coordinated these efforts, thus convincing Lin that his previous protests about a lack of authority over the merchants were nonsense. Thousands of chests of opium were handed over by the merchants for Lin and destroyed.

In April 1839, the blockade was lifted and Lin commanded that bonds be signed by all merchants that they would no longer smuggle opium, on pain of execution if found with the contraband.[7] This called into question the issue of jurisdiction, as the British citizens refused to be subject to what they regarded as barbaric Chinese law. This dilemma also drew in the broader question of whether the British regarded Chinese law as legitimate constraints on imperial trade interests at all, since the entire opium trade itself had flouted Chinese laws for decades.

After meeting with William Jardine, the top opium trader in Canton, Palmerston immediately wrote to the Prime Minister, William Melbourne, to discuss a military expedition. One historian, Brian Inglis, observed:

> The way the questions were put shows that Palmerston had already pre-judged the issue. The confiscated opium was not contraband, it was 'property.' The merchants from whom it was taken were not smugglers, they were 'suffering parties.'[8]

The ethical disparities over opium smuggling presented themselves most clearly in the form of failed appeals for cooperation from the Chinese side. In 1840, Lin wrote a letter to Queen Victoria, signed by the Emperor, which was entrusted to Captain Warner of the *Thomas Coutts*:

> Where is your conscience? I have heard that the smoking of opium is very strictly forbidden by your country... Since it is not permitted to do harm to your own country, then even less should you let it be passed on to the harm of other countries—how much less to China.[9]

Lin accused the British who condoned the opium trade as "careful of [their] own lives, but careless of the lives of other people, indifferent in [their] greed for gain to the harm [they did] to others. Such conduct [was] repugnant to human feeling, and at variance with the Way of Heaven."[10] Lin had attempted to send a previous letter in 1839, which was rejected by Elliot on the grounds of addressing the Queen on equal diplomatic terms. His second letter reached England, but was rejected by Palmerston in the Foreign Office, because Captain Warner had signed Lin's bond. The letter never reached the Queen or anyone in the British government.

It was evident from these events that to some extent, Palmerston already regarded Chinese laws and diplomats as subordinate to the Crown, and did not regard China as an equal diplomatic counterpart with full legal rights within its territories. The issue, then, was which British interests (trade revenues, legal jurisdiction, imperial prestige) would supersede its regard for Chinese laws enough to warrant force to ensure compliance. Historian Harry G. Gelber counted "the future arrangement of China's trade with the outside world and…the question of controlling China's coasts and borders" among the factors that Palmerston took into consideration in going to war.[11] These factors demonstrated that the war was not intended create an imperial relationship with China, but to validate by force what was already implicitly assumed in practice.

Opium Traders and the Imperial Distance

The merchants of Canton made it an open secret that they had been carrying cargoes of opium for decades, but staunchly avoided responsibility for opium's effects in China. They evaded ethical complications by depicting themselves as agents of government-sanctioned free trade, distancing themselves economically, culturally, and politically from the iniquities of the trade itself. William Jardine and his partner James Matheson owned the company (Matheson Jardine) that was the largest importer of opium into China. Jardine once wrote to a missionary boarding his ship:

> We have no hesitation in stating to you openly that our principal reliance is on opium…[which] by many is considered an immoral traffic, yet such traffic is so absolutely necessary to give any vessel a reasonable chance of defraying her expenses, that we trust you will have no objection…[12]

A pamphlet signed by "A British Merchant," (most likely either Jardine or Matheson), argued that the sale of opium was not immoral because "the people of China were only too willing to receive it. Surely, therefore, 'no morale will be urged against it.'"[13] Chinese people were culturally different and therefore somehow culpable for their addiction, or simply less immoral to exploit through abusive transactions.

The "merchants of death" also placed a political distance between themselves and their victims, offloading culpability to the British government and the Indian economy. The Committee of the London East India and China Association submitted a memorandum to Palmerston in 1839, pointing out that Parliamentary committees had enquired minimally into the trade, with a full knowledge of the destination and content of cargo as well as the amount of revenue it generated, and that it seemed "most unjust to throw any blame or odium attaching to the opium trade upon the merchants, who engaged in a business thus directly and indirectly sanctioned by the highest authorities."[14] British merchants in Calcutta wrote to the Privy Council, arguing that the opium trade was both "eagerly sought after by the Chinese people" and "fostered into its recent magnitude by every means that ingenuity could devise on the part of the British Government of India."[15] They pointed out that the government "consulted on every occasion the wants and needs of Chinese consumers," and provided charts showing that roughly 85% of the opium shipped out from Calcutta was dispatched directly in to China.[16] The contraband sale of opium, in the eyes of the traders, had always "flourished through the connivance of Government officers," and any blame on the merchants would be shared by government agents as well.[17]

One famous pamphlet circulated in 1840 was *The Opium Question* by literary talent Samuel Warren (to whom Matheson was a patron). In it, he argued that merchants could not be held accountable for the moral rights and wrongs of dealing the drug when the British government explicitly condoned the Company's activities.[18] Warren compared opium to smuggled French brandy or lace:[19]

> Has any British merchant engaged in the opium trade ever fancied, or had reason to fancy,--although carrying it on every moment under the eye, and paying tribute for it into the pocket of Government, that it was during these forty-three years *illegal*, except in mere name?[20]…Do we venture to call them smugglers?...Are they not some of our most eminent British merchants—men whose names would command respect and confidence in Great Britain and in India—in short, in every quarter of the world where commercial enterprise, honour, and good faith are known? [21]

Other merchants sent reports detailing the revenue that the opium trade brought annually to India, and forecasts of silver that would be lost to the crown if it were halted. If the opium trade dried up, "such was the dependence of the Indian economy on their efforts that commerce in general would come tumbling down in ruins… [having] a catastrophic effect on firms in Britain which had trading interests in the east." The silver bullion leaking out of Chinese coffers also purchased cargo to fuel Britain's own national addiction to tea. This elevation of the worth of profit margin to lives, where the quality of life to a British subject was more than the actual life of a Chinese addict, was only possible in an imperialist mindset buffered by a physical and cultural distance.

Richard Cobden, a critic of British imperial expansion, tried to acknowledge positive outcomes to the opium business: "[i]n a modern world of investment and trade, China and Japan could not possibly be allowed to remain isolated; and in any case, free trade was the blood-brother of international peace, welfare and virtue, even of Christian advancement."[22] Yet the Opium War expedition showed that the mantra of economic imperialism was above all to maintain favorable trade relations for the empire, whether it was with a free country or one under British control.

The Public and British Honor in the *Times*

The British public had little or no awareness of the events in Canton until London newspapers began reporting events several months after they took place. Palmerston did not receive news of the March 1839 blockade until August, and the London *Times* began reporting on the events at that time as well. British opinion appeared to be split on the ethical issues,

and the opium trade was not generally a topic of great national concern. The most salient matter seemed to be that the Chinese insulted British dignity and pride by mistreating the expatriate families during the blockade. In the debate over whether to go to war, both sides of the public debate tried to claim the high ground of regaining British honor and national prestige.

In August, 1839, the *Times* focused on publicizing the factual development of events in Canton, and reprinted primary documents forwarded from the *Chinese Repository*, an merchant-funded expatriate periodical from Canton. Presumably in an effort to show both sides of the controversy, the August 7th *Times* reprinted a merchant petition to the Queen requesting compensation for their lost property on the same page as an edict from Commissioner Lin. The merchants pointed out the capital benefits derived from the opium trade to the government, and appealed for a speedy redress of their violated property rights.[23] Lin, comparing the great benefits of the tea trade to British citizens to the great harm of opium imports to Chinese consumers, argued that British conduct would "rouse[] indignation in every human heart, and [was] utterly inexcusable in the eyes of celestial reason."[24] This emotional appeal was then followed by several haughty threats about how the great might of the Celestial empire, which stretched for thousands of miles, would put an end to British livelihoods.

Yet as the *Times* continued to report while events unfolded, a pattern emerged of public attention on British honor and prestige. The *Times* did print features by one or two prominent critics of opium, including an excerpt by Reverend Thelwall's book *Iniquities of the Opium Trade With China*. Nevertheless, it seemed that the British public was most aroused not by the moralistic accounts of opium's destructive effects in China, but by the sensational ignominies suffered by their countrymen by the hands of the brutal and vulgar Chinese barbarians. Contrary to Lin's mistaken belief, opium was not illegal in Britain and was commonly prescribed as a prescription drug, laudanum. Charming old ladies would take it nightly before bed, and it was seen as no worse than gin or tobacco. Lin, on the other hand, had committed an "unquestionable atrocity" by blockading and then expelling British countrymen by force, gravely insulting their honor and causing subjects of the Queen to lose face abroad.[25]

Less than a week after the first reports from Canton, the *Times* published another detailed, more sensational account of the blockade and events on the ground. The Chinese forces were reportedly using "intimidation" tactics, "threatening the lives of the Hong merchants," and "depriving the foreigners resident [there] of their liberty."[26] The story included excerpts written by Elliot to the Canton Press from March about the "dangerous, unprecedented, and unexplained circumstance…imminent hazard of life and property, and total disregard of honor and dignity" suffered by merchant families. Readers pieced together details from the scene, recalling from the last story "the threatening language of the High Commissioner… of the most general application, and dark and violent character."[27]

The subsequent forced expulsion of British families from Macao did even more to stir public anger at the insult to British dignity. Readers were offended to find out about English women and children being "exposed to dark and nameless insults and dangers at the hands of dirty Chinese ruffians."[28] Women were still placed on a Victorian pedestal of innocence and purity, and this above all galvanized Englishmen to call for action. Many might have echoed Samuel Warren's sentiments in *The Opium Question*:

> In the name of the dear glory and honour of old England, where are the councils which will hesitate for a moment in cleansing them, even if it be in blood, from the stains which barbarian insolence has so deeply tarnished them?...Why are there not seen and heard there, by those incredulous and vaunting barbarians, the glare and thunder of our artillery?[29]

The paradigm shift on the ethical grounds for war were noted and adopted by the opposition. On April 25, 1840, the *Times* reported on a Freemasons' meeting condemning the war. The speakers attempted to shame the government for pursuing a war that bungled "a question involving the honour of the British nation and our Christian character."[30] These groups opposed the war using the same language of maintaining British prestige by not fighting, as well as the religious and moral high ground of converting more Chinese through goodwill instead of violence. These sentiments were also imperialist in themselves, as they prioritized the reputation of British honor and good reputation abroad. The moral question of selling deadly drugs to Chinese addicts in contravention of jurisdictional law had been tabled and forgotten.

Skirting the Ethics: The Parliamentary Debates

After the Government sent an expedition to "obtain reparations for the Insults and Injuries offered to Her Majesty's Superintendent and Her Majesty's subjects," unconfirmed news reports of military operations began trickling back into London in early 1840. [31] By March, Palmerston had admitted to the expedition under repeated queries from the Opposition. Arguments over the war took place during three debates—all unsuccessful motions to excoriate the government's reasons and methods for going to war. On April 7, Sir Robert Peel moved to censure the Majority's expedition. This set off a three-day debate in the

House of Commons, which Palmerston won 271 to 261. Sir James Graham then brought a motion to ban the trade, which was again lost in the Commons. In the House of Lords, Lord Stanhope echoed the minority's condemnation, but the ensuing debate split the opposition position so that he was forced to withdraw his motion without calling for a vote.

In all these debates, the topic of opium was exceedingly awkward as both sides tried to navigate around thorny ethical issues like protecting opium production in India and British profits made from that revenue source. The Opposition focused its attacks on Government bungling its relations with Chinese officials and allowing misunderstandings to get this far, but was not opposed to fighting the war itself. Even William Gladstone, who eloquently denounced the moral vicissitudes of the opium trade, stopped short of demanding that the military operations in India come to a halt.[32] These omissions made the debate focused ethnocentrically on the issue of the British countrymen's honor. Moreover, the lack of minority resistance to the war itself undercut the opposition's claims to the moral high ground and revealed the underlying imperial motive behind both sides. Why would the opposition allow a war if they truly believed that the Chinese had the moral and legal right to try to stop the immoral opium trade, and that the British Government should have cooperated more fully with them?

In the House of Commons, speakers in the minority tried to occupy the moral high ground, but fell short of trying to put a halt to the expedition even as they called it an unjust war. Sidney Herbert said that Britain was "contending with an enemy whose cause of quarrel is better than [its] own, and that it was "a war without just cause" to "maintain a trade resting on unsound principles, and to justify proceedings which [were] a disgrace to the British flag."[33] William Gladstone further accused the entire British community of being involved in the traffic, and even pointed out how merchants and officials alike had been deceptive in saying they could do nothing about it: "Does the Minister not know that the opium smuggled into China comes exclusively from British ports, that it is from Bengal and through Bombay?...we require no preventive service to put down this illegal traffic. We have only to stop the sailings of the smuggling vessels…"[34] In a career-making speech, he claimed that "a war more unjust in its origins, a war more calculated in its progress to cover this country with permanent disgrace, I do not know and I have not read of."[35] Gladstone also appealed to the British sense of honor by rhetorically shaming the crown, calling the British flag a "pirate flag, to protect infamous traffic."[36] The fundamental hole in his reasoning was his omission of judgment on the treatment and jurisdiction of the British merchants in Canton. If his reasoning held true that opium trading was illegal piracy and that the Chinese had the jurisdictional right to enforce laws on their own coasts, there would be no reason to not allow them to expel criminals from their territories. By refusing to pass judgment on the value of "national honor," he left the debate open to the majority to emphasize the inherently greater value of British subjects' offended dignity, which outweighed considerations of Chinese lives or legal authority.

Along the majority bench, familiar themes of free trade incentives, unalterable addiction, and national prestige emerged in the speeches. In a three-hour opening speech, Sir James Graham reasoned that it would be unfair to bar British traders alone from participating in the lucrative business of selling opium, while other opium importers such as the Americans reaped the benefits. They would win Britain's market share in the opium business, and increase their profits by millions that would otherwise go to the crown.[37] Melbourne agreed that "opium was probably less harmful than gin and anyway it was the Chinese who insisted on smoking it…unless one reduced demand, there was no point in trying to strangle only one of several sources of supply."[38] Palmerston distanced the British culturally from the sins of addiction, blaming the Chinese for opium demand. Why was it on the shoulders of the British to consider "preserving the morals of the Chinese people, who were disposed to buy what other people were disposed to sell them?"[39]

The mantra of British imperial prestige emerged clearly in these debates. Sir G. Thomas Staunton cautioned the floor: "Parliament should remember that the entire British Empire was founded on prestige. If they submitted to insults from China, British political ascendancy would collapse."[40] Thomas Macaulay, the Secretary of State for War, argued that the Chinese government had the right to restrict opium but not to seize "our innocent countrymen, and insult[] the Sovereign in the person of her representative." Britain was going to war so that its subjects could "look with confidence on the victorious flag which was hoisted over them, which reminded them that they belonged to a country unaccustomed to defeat, to submission or to shame…surrounded as they were by enemies, and separated by great oceans and continents from all help, not a hair of their heads would be harmed by impunity…"[41] The war in Canton was essentially a signaling ground for British supremacy, to formally assert royal control over the resources of an region informally controlled by economic imperialism, and to demonstrate the empire's treatment of subordinate races who imagined themselves equal to the Crown.

Palmerston attempted to place the expedition in a less exploitative international context. In his closing speech, he argued that Lin "put down the opium trade by acts of arbitrary

authority against British merchants—a course totally at variance with British law, totally at variance with international law…"[42] The British were setting things right. It was ironic that he appealed to international law, British jurisdiction and sovereignty, because the whole incident arose precisely because the same considerations were not afforded to the Chinese. His final proposal further eroded the ground for international sovereignty: "The actions of the Chinese Commissioner had been 'unjust and no better than robbery'. A joint British, American, and French naval force should be stationed on the Chinese coast to look after Western interests."[43] However thinly masked the imperial motives, they were shared by a majority of the British Parliament. The Opium War forced open Chinese ports and crippled the Qing government's legitimacy, allowing the British to demand concession of China's coastal territories and economic resources to the imperial economy for the next century.

Conclusion

The relationship between British officials and the Qing government was notable in that the British were dealing with a fully-formed government of a foreign state rather than a colony of a protectorate which they already controlled. Yet the British government did not view China as a real government and diplomatic equal, but rather as an informal colony whose laws were not to be taken seriously and whose demands were an affront to the Crown. For opium merchants in Canton, the laws were made to be flouted, and the British economic interests warranted a willful disregard to the human suffering inflicted by the opium trade. This was made easier by the cultural distancing tactic of devaluing the lives of Chinese addicts, as well as the abdication of culpability to instead blame British government agents, who had condoned the trade for decades. For the British public and Parliamentary officials, the justification for war was to redeem the British reputation and prestige abroad, which had been sullied by Commissioner Lin's audacious treatment of English subjects as criminals. The opposition's supposed neutrality on China's anti-opium policies and the ethics of the opium trade met with an inherent contradiction when they allowed a war that defended the opium merchants as victims instead of criminals. Ultimately, both the justifiers and the opposition to the Opium War opted for an ethnocentric presumption in the interests of their countrymen and the British reputation abroad—revealing just how deeply the vein of economic imperialism was rooted in nineteenth-century British consciousness.

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The Role of Community Health Workers in Northeast Brazil

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Community health workers have received increased attention in recent years as many global health programs emphasize their potential for improving community health. Brazil is a modern example of a population that employs community health workers as part of its national healthcare system. This study investigated how these community health workers view the health of the communities where they work and moreover how their work shapes the community's health. I collected the data used in this study during a summer in Bahia, Brazil using both informal and formal interviews, and field observation to understand how community members, community health workers, and health professionals evaluate and conceptualize the health of the community. Special emphasis was placed on how the informant's relationship to the community—such as insiders/outsider status—may influence his or her perspectives.

Background

Paul Farmer recently spoke at Stanford about Partners in Health's new program in Rwanda, a program that relies heavily on community health workers. At Stanford's ThinkBig conference on international women's health and human rights, several of the speakers, including Paul Blumenthal, highlighted the role of community health workers (CHWs) in working toward improving women's health worldwide. Recently, the global health community is placing an increased amount of faith in community health workers to help implement health interventions and improve health outcomes. While the enthusiasm and support for community-based programs is growing, the body of research on community health workers still remains small. Before global and local health initiatives invest in programs that utilize CHWs to effect change, it is important to explore the roles of CHWs within communities and how community members perceive their work. These perceptions will influence the success of interventions: while there has been much talk about community health workers, it is more important to talk to them. This study uses the experiences of CHWs and their working relationships with community members and health professionals to help determine more palatable ways to integrate and employ the work of community health workers to improve global health outcomes.

Paul Farmer and Paul Blumenthal are not the only ones promoting the involvement of CHWs in global health. Community-based programs have gained popularity and are present today in many countries around the world. A community health worker may be "any health worker carrying out functions related to health care delivery; trained in some way in the context of the intervention; and having no formal professional or paraprofessional certificated or degreed tertiary education" (Lewin *et al* 2005). Generally community health workers function as intermediaries between community and institutional health care services. The training and responsibilities of CHWs can vary widely: some CHWs are volunteers, while others are paid; some are from within the communities in which they work, while others are not. In some cases, they may be trained to deliver basic health care and implement interventions, while in others, their primary role may be to deliver information about health and how to access health services.

Most of the existing research on community health work has utilized quantitative methods to analyze pre- and post-CHW intervention statistics to determine whether or not CHWs change health outcomes. A Cochrane meta-review of lay health workers in primary health care in the U.S. and in developing countries concluded that CHWs are successful at improving certain outcomes, such as immunization and the prevalence of breastfeeding (Levin *et al* 2005). Separate studies specific to Northeast Brazil (Macinko, de Fatima Marinho de Souza, Guinais, and da Silva Simoes, 2007; Edmond, Pollock, Da Costa, Maranhao, and Macedo, 2002; Cuvino, Vasconcellos, and Araujo Craveiro, 2000) similarly found that the presence of CHWs is associated with decreases in infant mortality rate, post-neonatal mortality, and mortality due to diarrhea, but not with neonatal mortality rates. After CHW intervention, breastfeeding rates, especially of infants 6 months and older, immunization rates, and the number of women receiving contraceptive advice from a physician all increased. These studies provide evidence for the effectiveness of CHW interventions in improving maternal and child health outcomes.

While these studies indicate that CHWs can have a positive effect on health outcomes, little research has addressed the best practices for CHW recruitment and training. A meta-study by Levin *et al* (2005) on lay health workers in the United States and around the world stated that best practices for recruiting, training, and delegating tasks to CHWs remain unclear due to insufficient research. Ultimately, it is not just the presence of CHWs that leads to change, but their individual operations, as well as the organization and design of the program through which they operate. What are the strategies and characteristics of CHWs who are successful at changing the behaviors of community members? How do community members view CHW

[1]Stanford University

interventions? What training processes and interactions between community members, health professionals, and CHWs take place that lead to improved health outcomes? How are health outcomes affected by the relationships between the CHW and the community, and what factors impact the relationships? These questions set the backdrop for this study of CHWs in the Brazilian national health care system. In particular, this study will address the respective strengths that both insider and outsider CHWs bring to the job, and potential differences in how they evaluate and conceptualize the health of the community.

The Family Health Program in Northeast Brazil

Brazil has a universal health care system that draws heavily upon primary health care and community-based health models. A crucial component is the Family Health Program (*Programa da Saúde da Familia*, or PSF), which was implemented in 1994 to increase primary care coverage. PSF clinics provide services focused on health promotion, disease prevention, and disease surveillance; these often include vaccinations and regular check-ups, prenatal care, and health education. The PSF clinics are staffed by one doctor, one nurse, other health professionals, and 6-12 CHWs. Each CHW is responsible for an area of approximately 150 families in the community. As links between the community and the PSF clinic, CHWs schedule appointments for individuals with the health professionals and encourage community members to seek care at the clinic (Ministry of Health, 2002). Because the community health program in Brazil has been in place for several years now, it provided a useful environment in which to study interactions between CHWs and community members, and their impact on the community's overall health.

Methodology

To answer my research questions, I designed and conducted a qualitative case study of CHWs in Brazil. During an 8-week stay in Brazil, I collected data from field observation, interviews, and participation in the community, focusing on perceptions of community health. I aimed to recruit a diverse group of CHWs for the study to help explore how an insider is defined within the community, and the strengths that both insiders and outsiders bring to community health projects. I choose these qualitative methods because I was specifically interested in how the concepts of an insider and community health are socially constructed and understood (Glesne and Peshkin, 1992). It was my goal to understand CHWs and how they contribute to community health within the context of the community and the PSF. I suspected that the dynamics between CHWs, the community, and the PSF are play important roles in how individuals talk about the system and the community's health. Living in the community helped me build relationships with informants and understand the data and their contradictions from a broader perspective, within a broader social and cultural context.

I interviewed twelve CHWs, and observed eleven of them on routine house visits lasting one to two hours. I talked to 17 community members and informally interviewed two nurses and two doctors at the PSF, as well as one nurse technician. While the focus of my study was CHWs and they comprised my main population sample, I also collected data from CMs to understand how CHWs are perceived in the community and to what extent CMs and CHWs share their views of the PSF. Health professionals were also a valuable subpopulation to include in the study since they are all outsiders, have received extensive formal training, and supervise the CHWs, and were able to provide a unique perspective on community health. The CHWs and health professionals were all employed by the local PSF clinic, and they were recruited by announcements at staff meetings. The CHWs who participated ranged in age from 23 years to over 40 years old; one-third were male and two-thirds were female.

After collecting all data, transcribing interviews and expanding field notes, I coded the data using inductive and deductive codes, generating the codes from my research questions, previous studies, and the data itself. I then grouped the codes into five major headings: interactions with community members, responsibility for health outcomes, perceptions of health, role perception of CHWs, and perceptions of PSF. A second round of analysis then looked at differences in these five themes across specific CHW characteristics, such as gender, age, and experience. Through several rounds of refining codes and writing conceptual memos (Miles and Huberman, 1994), I identified emerging themes and preliminary ideas about the data, and then tested several explanations for them.

Results & Discussion

Preliminary Theme: CHWs have fluid and dynamic responsibilities, not solely confined to a limited rigid set of tasks

Initial data analysis reveals several interesting contrasts within the perceived roles of CHWs and how these roles play out in the community. This paper focuses on how tasks of CHWs can vary dynamically depending on issues that arise within the community each day, and these tasks are carried out nearly anytime and anywhere; yet the tasks fall within a very limited and rigid scope. While all CHWs perform the same, narrow range of tasks approved by the government, CHWs work beyond the spatial and temporal boundaries of the PSF (the clinic and 8am-5pm, respectively), constantly adapting their work to respond to the daily events and needs of the community.

CHWs must be flexible and ready to respond to issues in the community as they arise

There were several times during the summer when community members or CHWs pointed out instances that were prototypical of the CHW's work, highlighting the fluidity and dynamic nature of the work. I first noted this in my field notes while I was shadowing Anna, a CHW, on house visits.

> We are on the street near the PSF clinic, when a middle-aged man approaches Anna with a list of three medications and says he needs refill prescriptions. He gives Anna the address of a hotel in the city center and asks her to drop off the prescriptions there. Anna smiles and sighs as we walk back towards the clinic to get the prescriptions from the doctor. "You see?" she says to me. "This is the work of the CHW." (Anna Observation, July 20)

This short encounter illustrates the spatial and temporal boundaries of the CHW's daily work, which are often fluid; interactions between community members and CHWs are informal, and can take place anywhere in the community and at any time. While most of their work involves house visits, CHWs are also expected to respond to community members needs as they arise. This scene also illustrates the CHW's role as a liaison between the community members and the health professionals at the clinic; the man was able to approach Anna on the street in a way that he would not approach the nurse or doctor, and Anna was able to interrupt the doctor for a few minutes in order to have her write the prescription.

Another situation I observed in São Pedro also illustrates the informal nature of the work, how much of it is conducted on the street, as well as how the CHWs respond to unexpected events and changes in their usual schedule. Julia, the CHW, was on her way to the neighborhood where she conducts house visits, when she ran into community members who told her that a woman in Julia's area had left her baby with some neighbors. Julia knew the woman and was concerned about the situation, so she postponed house visits until she was able to seek advice from the PSF nurse, and then locate the woman and her baby. *"You see?" Julia says to me as we finally begin house visits. "This is what the job of the community health worker is"* (Julia Observation, August 11). The CHW's job is dynamic and constantly caters to current and day-to-day issues in the community. Community members seek CHWs out to help resolve personal and community issues.

These scenarios are also representative of the relationships of interdependence between community members, CHWs, and health professionals. The community members depend on the CHWs to resolve varied issues—from filling a prescription to keeping tabs on a neglectful mother—and they are able to approach CHWs informally, in a way they are not able to seek out health professionals. The CHWs, in turn, need the support of the health professionals in order to fulfill their responsibilities. The most common task of the CHW is referring community members to see the health professionals. The health professionals, however, also are unable to do their work without the CHWs updating them on the health of community members.

Dr. Alicia, the nurse in Itacaré, cited the PSF team's response to a boy with meningitis in the community as a perfect example of the role of the CHW and how it fits within the role of the PSF as a whole:

> Did you hear about the boy with meningitis? That is a perfect example of the PSF in action. Without the CHWs, we might not have known about the case for two days, maybe 2 or 3 days…but we found out right away, and we had to do the block-off, you saw, right? Give everyone meds who had been in close contact with him…preventing more outbreaks. That was a really good example of the PSF's work.

Again, this scenario was a sudden event, and the CHWs and health professionals had to work as a team to respond quickly. Dra. Alicia knew which medication to prescribe, and the CHWs knew the families that had been affected and where they live. In this sense, the CHWs are not only liaisons between the community and the PSF, but they are the eyes and ears of the PSF.

Anna, Julia, and Dr. Alicia all emphasize the dynamics and diversity of the day-to-day activities of CHWs.

Luis gave one specific example of a CHW activity, checking children's vaccination cards, that reveals his perception of the more abstract role of the CHW within the PSF, by filling in the missing link between the health services provided by the PSF and the community members' health. Luis beautifully summarizes the role of the CHW by saying, "now there's someone checking the card."

> When I started working I'd say 50% of mothers didn't pay attention to the vaccine schedule. And it was also that they didn't understand the card. They would bring their newborn to the clinic, the nurse would give a shot and mark in their little card, and they'd go home without understanding the whole schedule, that they had to come back on such and such date. Before they didn't have someone coming to their house and checking the card, and explaining. Now there's someone checking the card.

The goal of the PSF is prevention, which requires the CHWs to proactively connect the community members with the health services. The health service itself, providing immunizations, would be

ineffective without CHWs. They not only helped decipher the paperwork, but also held community members accountable for following through with appointments.

Rigidity of the Tasks Appropriate for CHWs

The CHW occupies a very clear and defined space within the PSF. While CHWs are not always satisfied with what that space, or role, entailed, they did not imagine or entertain the idea of changing or expanding the role. For example, many CHWs agree that their work would be more efficient if they were trained to measure blood pressure, but explained to me that if they were trained to do that, they wouldn't be CHWs anymore; they would be nurse technicians. When I asked Taís whether she would like to be able to take blood pressure, rather than enlisting the help of the nurse, she replied, "*No, for that I'd have to be a [nurse] technician, and I'm not a technician, I'm a CHW."* Anna, another CHW, echoed a strong identification with the CHW role, and the tasks that are within and outside its realm:

> The only people who can take blood pressure are nursing assistants and professional nurses…We CHWs are neither nurses nor nursing assistants. Our role is to advise…they could train us, because I already know how to [measure] blood pressure. But it's to protect the Secretary of Health, because I could do it all wrong, so they prefer that the professionals do it. They are the ones responsible for it. The CHW can't even tell patients to take one little pill, because he is not a doctor…it's only to orient the community about health.

The positions within the PSF are defined and understood by specific tasks, and measuring blood pressure is within the nurse technicians' domain. Although CHWs are not always content with the limited scope of their tasks, they have internalized the official roles of each PSF employee, such that receiving additional training automatically promotes them to a level above community health worker. This perspective reflects the rigidity of the CHW role. While it is a dynamic and fluid role in that the work spans a range of places and times and involves unexpected events, only a distinct and restricted subset of tasks are associated with the CHW role.

Implications for Community Health Programs

These emerging themes are just one small piece of the process of answering larger questions of community participation and community agency in working towards improving community health. While many people working in global health and community health are enthusiastic and optimistic about incorporating community health workers into health interventions, still relatively little is known about how to best incorporate CHWs into existing and new health systems. How community members and CHWs themselves conceptualize the CHW role has crucial implications for the extent to which CHW interventions will be successful. It is possible that expanding the scope of the CHW role, such that it includes tasks such as taking blood pressure that are now associated with health professionals, may help legitimize the CHW role and increase community membersí utilization of CHW services. Providing training that would allow CHWs to have as much flexibility in their skills as they currently have in their schedules may increase the effectiveness of CHWs. Overall, understanding the how the CHW role is constructed within the community and health system, and its influence on perceptions of health can help inform best practices for CHW recruitment and involvement. The results of continued research on community health workers will bring the public health community one step closer to understanding the optimal approach to understanding and fulfilling the goals of community-based development.

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An Analysis of Stratum Corneum Drying Stresses in Response to Moisturizers and Cosmetic Use

Allison Rhines[1]

Environmental conditions and the use of various skin care products have been demonstrated to cause damage to the outermost layer of human skin, stratum corneum (SC), in the form of cracking, chapping, and dermatological conditions of more striking severity. While the causes of cracking are well-understood from a biochemical perspective, their explanation from a mechanical perspective remains less well studied. Such a mechanical approach allows for the study of cracking as the buildup of drying stresses. Applying this approach, the research presented in this paper builds on the novel use of wafer curvature to the detection of such stresses in organic materials in a study of a sample of widely used moisturizers and cosmetics. While some of the experiments simply highlighted the moisturizing properties of lipsticks, more notable were the results of moisturizer experiments suggesting that the "tightness" felt by users of such products can be explained by drying stresses developing in the product itself, rather than in their own skin.

Introduction

Human skin is constantly exposed to conditions which lead to the drying of stratum corneum (SC), its outermost layer. These conditions include environmental factors such as ambient temperature and humidity as well as various hygienic, cosmetic and other personal care products that cause skin damage. According to Wu. et al, the resulting dryness can cause stresses to build up in the SC, cause SC to crack, interfere with normal shedding of dead cells, prevent the natural healing of damaged cells, and lead to an array of dermatological conditions. While the drying of SC and prevention thereof are well understood from a biochemical perspective, there has been little attention given to the interpretation of these phenomena as mechanical stress build ups (Wu et al., 2006).

Mechanically, the cracking of skin can be explained by buildup of stresses that develop as SC dries. When accumulation of tensile stresses surpasses what the SC can sustain, a mechanical driving force cracks the skin. Levi et al. demonstrated that such stresses can be quantified in a novel method that uses wafer curvature, a tool of materials science traditionally applied to thin films. Wafer curvature operates on the principle that as a sample dries, its curvature continually changes. As curvature can be measured periodically with a laser beam, and stresses in a sample can be calculated from curvature measurements, this method allows for the detection of drying stresses at regular intervals (Levi et al., 2008).

A variety of products exist on the market to combat these drying stresses. The majority of existing moisturizers can be divided into two categories based on their mechanism of maintaining a balance of water in the SC, thereby minimizing drying stresses. Those that act by conserving the skin's natural moisture are referred to as occlusive agents, and those that contain ingredients that bind water to add additional moisture to the skin are called humectants.

This project aims to advance the prevention of SC damage and associated medical conditions by analyzing drying stresses when SC is treated with various moisturizers and cosmetics, thereby evaluating their effectiveness at preventing drying of SC. This paper presents a sample of widely used moisturizers and cosmetics. While it is well understood that drying is often associated with SC stress, specific moisturizers have yet to be investigated: determination of the magnitude and type of drying stresses associated with these moisturizers, if present at all, will be discussed. Two occlusive moisturizers, sunflower seed oil and Petrolatum, were studied. Two cosmetics, a lip gloss and a lipstick, referred to hereafter as dry lipstick and moist lipstick respectively (names chosen for associated stresses rather than cosmetic consistency), were also examined.

Materials and Methods

The methodology used in this study rests on the aforementioned novel use of wafer curvature. Wafer curvature uses the changes in curvature of a substrate as it dries to measure stresses that develop in this process. As a sample dries, the buildup of tensile stresses causes the flat substrate to bend, curving it in a way that can be measured over time. Such a sample is scanned periodically with a laser, which projects a beam onto the substrate that is in turn reflected to a detector that measures the angle of deflection in relation to the position of the substrate. Changes in curvature are calculated from changes in position; stresses are then calculated from changes in curvature.

Two types of experiments

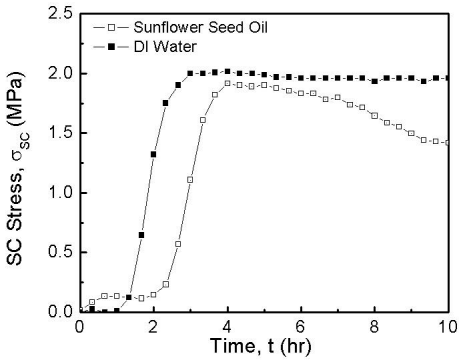

Figure 1: Stresses in sunflower seed oil on SC.

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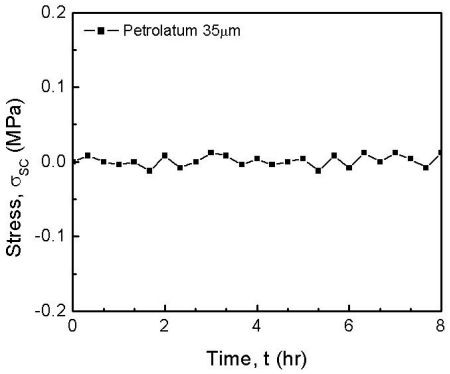

Figure 2: Petrolatum on glass slide stress.

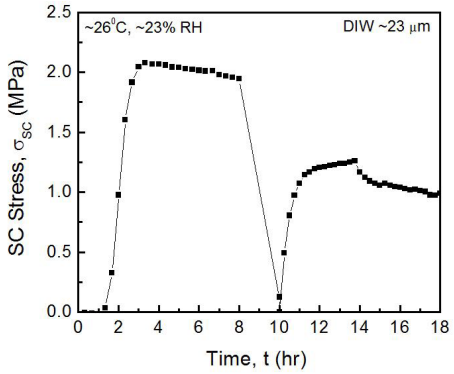

Figure 3: Stresses in petrolatum on SC.

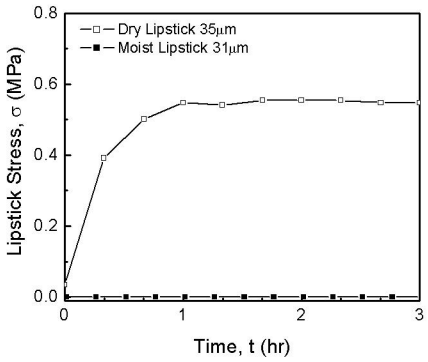

Figure 4: Stresses in dry and moist lipstick on glass slide.

were conducted in this study: those investigating the drying stresses in the isolated material, and those that measured stresses in SC to which the material had been applied. In the isolated material experiments, a thin layer of product was applied to a metal-coated borosilicate glass slide, and drying stresses were measured for 8 to 18 hours using wafer curvature.

Experiments using SC were conducted in the following manner. In preparation, tissue was harvested from Caucasian female donors; SC was detached from epidermis, dermis and subcutaneous fatty tissue in a mechanical heat separation. Thickness of SC was measured with a digital micrometer.

Liquid treatments, the distilled water control and sunflower seed oil, were applied as follows. Samples were soaked for twenty five minutes in distilled water and affixed to a wafer curvature substrate as they were removed. A borosilicate glass slide was used as a substrate; the slide was placed on a piece of filter paper and placed under the tissue sample in the distilled water bath. Water was drained leaving the SC secured to the substrate and free of wrinkles; excess water was removed from the surface of SC tissue. Samples were then submersed in the treatment for five minutes and excess tissue was separated from the sides of the substrate with a razor. Excess water was removed from the surface, and wafer curvature measurements were taken every fifteen to twenty minutes over an eight to ten hour period depending on the experiment.

For viscous treatments, Petrolatum and the lipsticks, the SC slide was prepared in the manner of the distilled water sample described above. The drying stresses were measured in an eight-hour distilled water experiment as a control. After 8 hours, the sample was placed in a humidity chamber for two hours until the stresses returned to 0. Treatment then was applied by spreading a thin layer across the SC, and drying stresses were measured for 8 hours.

Results

Tensile stresses in sunflower seed oil treated tissues increased steadily before reaching peak stresses of about 1.8 MPa after four hours and subsequently declined steadily. Stresses also increased in the distilled water control before reaching about 2.0 MPa after about two hours and remained constant (Figure 1).

In the Petrolatum only configuration, stresses remained relatively constant (Figure 2). In the Petrolatum on SC configuration, treated tissues exhibited peak stresses of 1.3 MPa as compared to the distilled water control with maximum stresses of about 2.2 MPa (Figure 3).

In the dry lipstick on glass slide test, stresses reached about 0.55 MPa after 1 hour. (Figure 4) No stresses developed in the moist lipstick (Figure 4). In SC tissue treated with dry lipstick, stresses reached about 1.3 MPa compared to the 2.25 distilled water control (Figure 5). In the SC treated with moist lipstick, stresses reached 1.3 MPa compared to the about 2.1 MPa distilled water control (Figure 6).

Discussion

Firstly, it should be noted that the success in detection of drying stresses confirms the results of Levi et al. concerning the reliability of this novel method in measuring stress buildup in the SC.

In the case of the sunflower seed oil, it is unclear whether the reduction in stresses in the treated tissues as compared to the control, is significant. However, there are two remarks about the use of sunflower seed oil that can be made: firstly, there was a 100% time delay (2 hours) in the development of those stresses, and secondly, while the control sample maintained maximum stresses for the remainder of the test, in the sunflower seed oil treated tissues a steady decline in stresses began once maximum stress was reached. Although further experiments would be needed to confirm these results, this data suggests the use of sunflower seed oil may be a strategy to reduce and delay drying stresses in SC.

A comparison of the stresses in dry versus moist lipstick reveals the superior ability of moist lipstick to

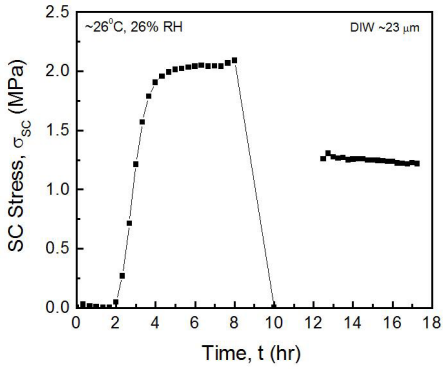

Figure 5. Stresses in dry lipstick on SC.

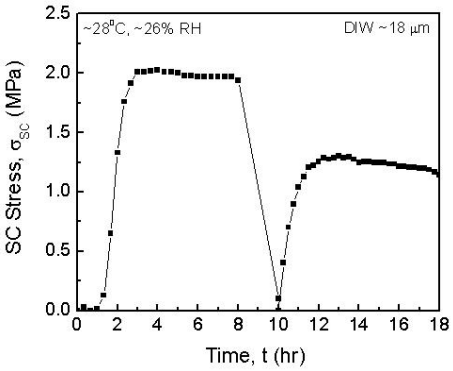

Figure 6: Stresses in moist lipstick on SC.

prevent drying stresses in SC (Figure 4).

The fact that all treatments produced some drop in stresses suggests that the moisturizers provide some non-neutral benefit to drying SC, and that both cosmetics may serve also to prevent the development of drying stresses, thus serving as "moisturizing" agents as well.

Most notable however, is that while all treatments show differing stress values in isolation, when applied to SC, stresses in all treatments remained constant between 1.25 and 1.4 MPa. All treatments which produce differing stresses in isolation, however, cause nearly identical drying stresses when applied to SC. To assume curvature is additive (and as stress is calculated from curvature), suggests a surprising drying behavior of these materials: in the composite, stresses may develop not in the SC but in the material applied to it. Thus, the characteristic tightness of dry skin felt by the consumer are in fact not a result of drying stresses in his or her SC but in the product itself.

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Learning to Select Robotic Grasps Using Vision on the Stanford Artificial Intelligence Robot

Lawson Wong[1]

Grasping is an essential ability for manipulation; for robots such as the Stanford Artificial Intelligence Robot (STAIR) to be resourceful in real-world environments, they must know how to grasp. While this is a well-studied problem in the case when a full 3-D model of the target object is known, it is difficult for real-world scenarios, where the robot must rely on imperfect perception to model the scenario. This paper presents a novel approach for grasping that only uses local 3-D information acquired from sensors. Given data of the environment from 3-D sensors, our algorithm generates arm/hand configurations that may potentially achieve a good grasp, then computes features of these candidates to select the best candidate and execute its grasp. These features capture desirable properties of potential grasps based on sensor data, which our learning algorithm then uses to predict how likely the grasp will be successful. This algorithm was tested on STAIR in real-world grasping of single objects and of objects in cluttered environments. Significant improvements in both cases were found.

Introduction

As the field of artificial intelligence becomes increasingly advanced and integrated, it is time to revisit the half-century old "AI-Dream," where intelligent robotic agents were envisioned to interact with the general human population. To this end, the Stanford Artificial Intelligence Robot (STAIR) project aims to introduce robots into home and office environments, where they will facilitate and cooperate with people directly. In order for robots to have any non-trivial use in such environments, they must have the ability to manipulate objects, which is provided through robotic arms. An arm usually has a manipulator "hand" attached at the end to allow finer manipulation and, more importantly, grasping. The ability to grasp is crucial; if we were unable to grasp with our hands, we would find it very difficult to perform essential tasks such as eating, and more complex actions such as cooking and working in an office would definitely be unachievable. A robust and infallible grasping system is therefore necessary for STAIR to achieve its goal.

In this paper, a novel approach for robotic grasping will be discussed. By considering information acquired from our 3-D visual sensors, we developed a reliable and efficient grasping system for STAIR that works in unknown and cluttered environments.

Background

The problem of robotic grasping has existed and has been well studied over the past few decades. The conventional approach use the forces applied by the fingers on the object at their contact points to determine whether a stable grasp can be achieved[1]. While in theory this fully determines the result of the grasp, this approach is not practical because a complete and precise model of the target object is necessary. If the model was inaccurate, force computations would likely be incorrect. When working in unknown and dynamic real-world environments, STAIR can only acquire a model of the environment through visual perception, which is subject to inaccuracies and incompleteness. In practice, applying force computations directly on these models leads to poor results.

The limitations imposed by perception have spurred interest over the past two decades in vision-based grasping systems. In particular, it has been found that perception of 2-D planar objects usually suffers from fewer problems. For such objects, the object

Figure 1: STAIR grasping from a very cluttered environment.

[1]Stanford University

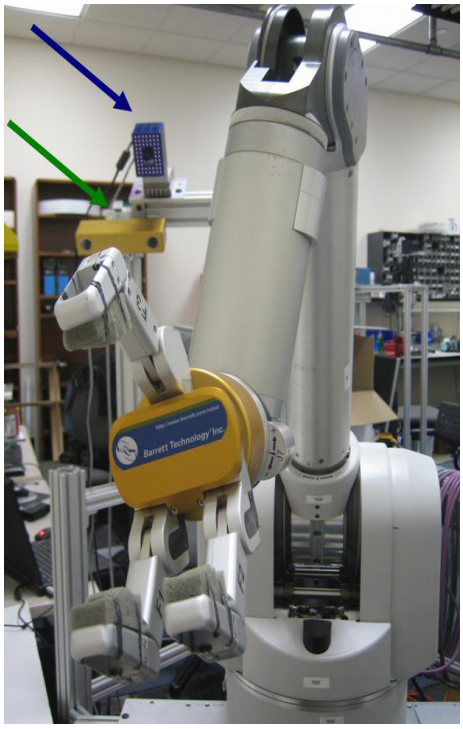

Figure 2: STAIR. 7-dof Barrett WAM Arm and 4-dof 3-fingered BarrettHand with "open" spread pictured. The spread can be "closed" such that all 3 fingers will be at the top. Vision system mounted on robot frame; blue arrow marks SwissRanger, green arrow marks Bumblebee2.

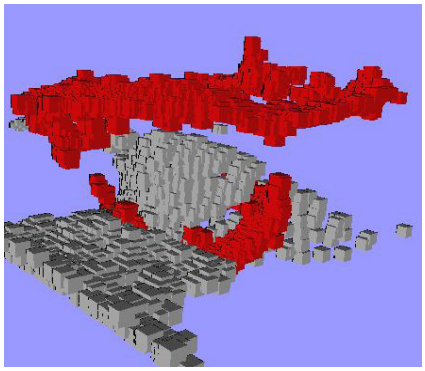

Figure 3: Imperfect perception. Original bowl, and the point cloud obtained via vision (shown in simulation). Red points come from Bumblebee2, gray points from SwissRanger. Only some edges are picked up by the Bumblebee2, and neither the bowl surface or table is seen. The SwissRanger gives a much more complete bowl front face and table, but no other side of the bowl is seen. Interestingly, the two cameras complement each other in this scenario; however, the perception of the bowl is still far from complete.

surface contour can be found reliably from vision. Criteria for successful grasps, derived from the mentioned theoretical force computations, can then be found for the object[2,3]. A similar approach was used by Kamon, Flash, and Edelman, where features indicative of successful grasps were computed given a 2-D image of the object[4]. A learnt model then used these features to compute an overall grasp quality, which predicted whether a grasp would succeed or not. While their results are promising, the methods are limited to 2-D objects and generalize poorly to the 3-D scenarios that STAIR faces.

Robot Description

The STAIR robot that this project is targeted for consists of a 7-dof arm (WAM, by Barrett Technologies) situation on a mobile platform. The arm is equipped with a 3-fingered hand with 4 degrees of freedom, one for each finger and one for the spread of the fingers (varying between being adjacent to each other and where two fingers are opposite the middle finger) (see Fig. 2). The arm is capable of reaching objects within a 1m radius. The hand can close its fingers inwards until the fingers hit an object, which is useful for grasping.

STAIR is also equipped with two cameras mounted on the robot frame. A stereo camera (Bumblebee2, by Point Grey Research) captures a 640*480 image using both its lenses, and uses the image differences to compute the depth for each image pixel, thereby giving 3-D point information. We shall refer to the set of 3-D points returned by the camera as the scene's "point-cloud." The point-cloud returned by the stereo camera is very incomplete, as stereo correspondences cannot be found for regions without texture such as object surfaces and tabletops, and only the front face of objects can be detected (the back face is occluded). To compensate for this missing information, another camera (SwissRanger, by MESA Imaging) provides a 144*176 array of depth estimates by firing an infrared light source and measuring the time it takes to reflect back to the camera. While this gives a much more complete image of the scenario, the data points are relatively sparse, and object surfaces that absorb or scatter the light are undetected by the camera. While the point clouds from STAIR's vision system are relatively accurate, they clearly still suffer from large amounts of missing data, hence an approach that does not apply force computations to evaluate grasps is necessary (see Fig. 3).

Approach

The objective is to, given a model of the environment through visual perception, determine a robot configuration (joint angles for the arm and hand) such that, when closing the fingers at that point (until they are fully closed or they hit an object), some object in the environment is successfully

Figure 4: 2-D image-based classifier identifying potential grasp points (depicted in red squares)[5,6].

grasped. This configuration shall be denoted as a "grasp." A successful grasp is defined here to be where the object can be lifted up into the air (such that the table is not supporting it) without it falling out of the hand.

We split this problem into two parts. We first find a set of likely candidate configurations that may achieve a good grasp, then use features of these candidates and a learnt model to score each of the candidates, and finally execute the highest scoring grasp. The first component has already been addressed by previous STAIR work on grasping[5,6,7]. Specifically, a 2-D image-based classifier uses the images from both cameras to select a set of corresponding 3-D points that are likely to be good grasp points (see Fig. 4). Given a 3-D point, there are still many orientations at which the arm can reach that point (and very few result in successful grasps), hence orientations are uniformly sampled for each point. These point-orientation pairs are then converted to joint angles, giving the corresponding robot grasp configuration. This forms our candidate configuration set.

The second component is inspired by the work of Kamon, Flash, and Edelman as described in the background section, where features of grasps are extracted and used to determine the "quality" of a grasp. The motivation behind this is that while force computations on perceived objects do not perform well and are inefficient, there are local properties of a grasp that inform us whether grasping at that location will be successful. There are several advantages to using local information. First, the most important 3-D region to consider for grasping is the region where the grasp will occur; little can be gained by considering the ends of a stick that we grasp in the middle. Second, while the vision data is incomplete, its *distribution* of incompleteness is very skewed; a bowl will have most of its front face perceived by the SwissRanger, but most of the back half would be missing. Hence we can get a more complete model when we grasp at the front face. Finally, there are usually much fewer points in the local region, which significantly speeds up computation. The previous work was limited to 2-D information, hence more sophisticated features, as described in the next section, will be computed using our 3-D local point cloud. A supervised learning algorithm will then be used to train a classifier based on these features, which can then be used to predict a score between 0 and 1 of the quality of a candidate grasp.

```
1.  Acquire 2-D candidate grasp points set from camera images using classifier[5,6,7]
2.  Use camera depth information to find corresponding 3-D candidate grasp points set
3.  FOR each grasp point in 3-D candidate grasp points set DO
4.      Sample orientations from 3-D orientation space
5.      FOR each orientation sampled DO
6.          Use arm inverse kinematics to generate configuration with hand center near the
            3-D grasp point and satisfying the 3-D orientation chosen.
7.          Select a finger configuration (sample spread and finger opening) that does not
            result in arm and hand colliding with obstacles
8.          Add arm/hand configuration from 7 (if any) to candidate configuration set
9.      END FOR
10. END FOR
11. FOR each configuration in candidate configuration set DO
12.     Compute features using the configuration and its hand's local point cloud
13.     Score[grasp] := score from classifier given features from 12
14. END FOR
15. WHILE grasp not executed AND candidate configuration set not empty DO
16.     grasp* := argmax Score[grasp]
17.     Plan path to execute grasp* using Probabilistic Roadmap motion planner[9]
18.     IF plan successful THEN execute plan
19.     ELSE remove grasp* from candidate configuration set
20. END WHILE
```

Table 1: Algorithm for grasping an object

The described procedure for grasping an object is summarized in the algorithm in Table 1.[8]

Features

Three main properties of grasping were considered. First, the grasp must be able to achieve good contact with the target object, otherwise the object may be entirely missed by the hand. Second, the grasp should be stable, so in particular an object should not be grasped at a tip or corner when that is unnecessary. Third, the grasp must be able to apply forces on the object effectively, which is dictated by the direction and orientation of the grasp; for example, consider grasping a long tube along its axis versus perpendicular to its axis. A total of 19 features were developed under these three categories.

The contact between the hand and the object can be approximated by presence of point-cloud points inside the hand. Intuitively, the more points within the volume of the hand, the bigger the grasping area and volume of the object, hence the less likely a miss will occur. Similarly, if there are very

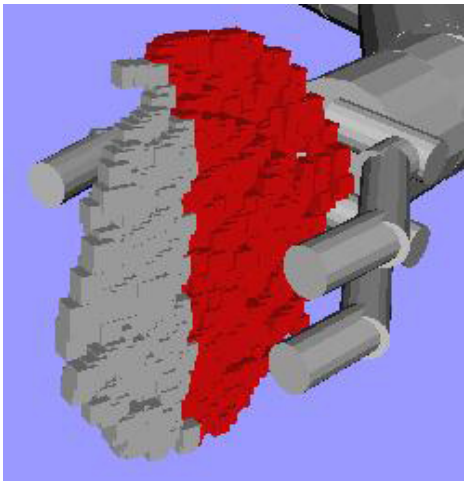

Figure 5: The cubes represent the local region. The red points within the local region denote the edge region.

few points within the hand, the grasp may likely fail because the points may just have been noise (where the hand will grasp air) or may have been a small tip of the object (where the hand should grasp some other part of the object). We therefore simply count the number of points within the local region, defined to be a sphere with 10cm radius centered at the hand center. Just counting this region however is insufficient, as an object may be near the hand but is not in the grasp (since the region is larger than the hand's grasp). Hence the points in the actual grasp region, i.e., on the inside region of the fingers, are also counted. The last region that was counted is a special "edge" region, defined as all points in the local region not extending further than the fingertip's reach (see Fig. 5). This region usually defines the edge of the object, hence the given name. Note that this feature has certain drawbacks, as small objects will naturally have fewer points but should not be undesirable to grasp; such subtleties are accounted for by the training set and the learning algorithm.

Stability of a grasp depends on the distribution of the object within the hand, or in our case, the distribution of the point cloud. Ideally, about the center of the hand, the point cloud should be evenly distributed along all axes. The outward axis from the hand is accounted for by the previous feature; if not enough points are within the hand, especially within the edge region, the grasp will be marked as bad. The "horizontal" axis, defined to be the axis between the fingers (when the outer fingers are directly opposite the middle finger), is not too important. A skewed distribution along this axis means that when closing the fingers to grasp, the closer finger(s) will push the object towards the farther finger(s), which is not a problem. The final "vertical" axis, which is normal to the other two axes, needs to be accounted for. Denoting one side of this axis about the center as "above" and the other "below," we desire that the number of points above and below the hand center to be near a 1:1 ratio (see Fig. 6). We therefore compute this feature by

$$\left| \frac{1}{2} - \frac{\text{Points above}}{\text{Points above} + \text{Points below}} \right|$$

, which is the absolute difference between the ideal (where points above = points below) and actual distributions. We also consider a similar measure where we only count points strictly above and below the hand (not enclosed by the hand). These measures are also computed with both the local and edge regions to increase robustness towards different cases; for example, the second measure may be more useful when considering large objects. The previous feature category combined with this therefore account for grasp stability.

Apart from being stable, it is more important that the forces of a grasp must be applied effectively on the object. Intuitively, an object should be grasped at narrow sides and not at wide sides, as at narrow places a tight closure on the object can be easily achieved, whereas at wide sides this is difficult (if the side is wider than the hand, then it is impossible). To capture this intuition, we consider the principal components of the local and edge regions. Using singular value decomposition (SVD), we obtain three orthonormal component directions u_i with variances σ_i, with σ_1 largest and σ_3 smallest. The larger the variance, the more important the direction is in defining the region; for example, for a plate, u_1 and u_2 will lie on the face (with large σ_1 and σ_2), whereas u_3 will be normal to the plate (small σ_3) (see Fig. 7). If we consider the unit horizontal axis vector h (axis running between the fingers), which is the direction in which the fingers close, we want h to be parallel to directions with small variances, and orthogonal to those with large variances. We therefore compute the directional similarity

$$s_i = |u_i \cdot h|$$

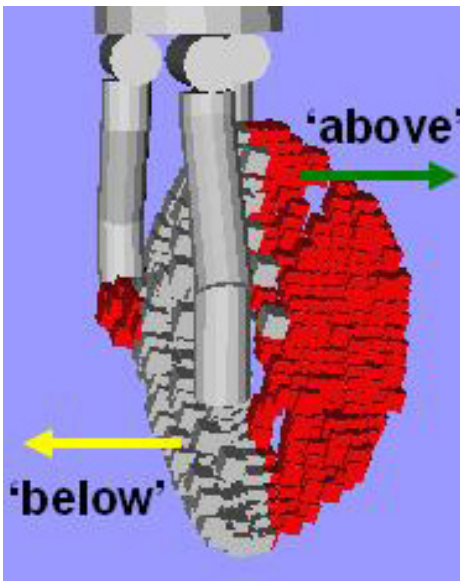

Figure 6: Definition of being above and below the hand. Red points denote regions strictly above and below the hand (not enclosed in hand).

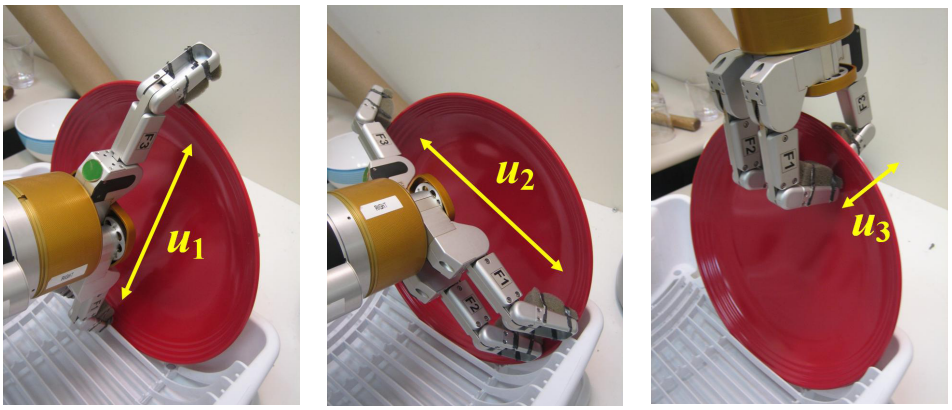

Figure 7: Example of principal component directions of plate. u_1 (left), u_2 (middle) lie on the plate, whereas u_3 (right) is normal to the plate. Only this direction gives good grasps.

for each component direction, which is large when u_i and h are parallel. Hence we desire that s_1 be 0 and s_3 be 1. We therefore measure this by computing the difference between the directional similarity and its ideal value by

$$\left(\frac{\sigma_1-\sigma_i}{\sigma_1-\sigma_3}-s_i\right)^2$$

Depending on how large σ_2 is, it may or may not be desirable to grasp in the direction of u_2. These features therefore capture whether the grasp configuration has a good orientation.

The features from all three categories were computed for a training set of 300 grasps, consisting of an equal number of good and bad grasps on plates, bowls, and wooden blocks, and achieved an 85% average test set accuracy when using 10-fold cross validation.

Experimental Results

We first considered grasping single objects from 13 novel classes (i.e., of different types from the training set) in a total of 150 experiments. These objects also differed significantly in size, shape, and appearance. In each trial, one object was placed randomly on a table in front of the robot. STAIR was able to achieve an overall grasp success rate of 76%, which is an improvement from the 70% achieved previously[9]. Moreover, the success rate was much higher at 86% for objects that were 1.5-3 times the size of the hand.

We also conducted grasping experiments in cluttered environments, which was the main objective of this project. In a total of 40 experiments, where more than 5 objects were placed randomly but close to each other, STAIR had to avoid hitting other objects and grasp a single object from the scenario. Although this was a significantly harder task in terms of perception, manipulation, and planning, STAIR had a success rate of 75%.

The videos and results of the experiments are at: http://stair.stanford.edu

Conclusion

We presented a robust and efficient algorithm that, given a 2-D image and 3-D point cloud of the environment from STAIR's vision system, can generate candidate grasp configurations and use local point cloud features to select a good grasp. The algorithm has been tested in simulation and in real-world experiments on STAIR, and has achieved significant improvement compared to previous systems, especially when grasping in cluttered environments. To further improve the algorithm, more features that describe general properties of grasps should be developed, and more grasp candidates should be searched and evaluated to increase the chances of finding and selecting an optimal grasp. In particular, instead of randomly sampling hand orientations uniformly from 3-D orientation space, better candidates can be found by applying heuristics to prune the search space. Eventually, we also hope to provide STAIR the sense of touch via force feedback, which would be extremely helpful in determining whether a secure grasp has been made yet. The challenge is to integrate all these components into a robust system without compromising for efficiency.

Acknowledgments

More details of the algorithm and results can be found in Saxena, Wong, Quigley et al.[6], Saxena, Driemeyer, and Ng[7], and Saxena, Wong, and Ng[8]. This project would not have been possible without all members of the STAIR Perception-Manipulation team and their efforts to develop and expand the functionality of the STAIR robots. Special thanks also to Ashutosh Saxena and Professor Andrew Ng for providing guidance for this project.

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The Role of Transcriptional Corepressor CTBP in Adult *Drosophila* Peripheral Nervous System (PNS) Development

Lila Cheung[1,2] , Mark Stern[3], Yutaka Nibu[3]

Regulation of gene expression is crucial for the development of all organisms because it controls cell fate specification and morphogenesis. One of the most common ways to control gene expression is through transcriptional repression, which is mediated by proteins that either directly or indirectly bind DNA. These transcriptional repressors act to turn off gene expression by attenuating mRNA synthesis. In our studies, we focus on a specific protein called the C-terminal Binding Protein (CtBP). This protein is known to function as a corepressor that is unable to bind DNA by itself but interacts with other sequence-specific DNA-binding repressors to inhibit the expression of certain genes. In fact, previous studies have shown that human CtBP either directly or indirectly interact with other transcriptional factors. Impaired or ectopically gained CtBP-mediated repression can lead to a myriad of birth defects and cancer (i.e. breast cancer, leukemia). Because CtBP is evolutionary conserved, we examined the role of CtBP in *Drosophila* peripheral nervous system (PNS) development as a model system. Through this study, we hope to better understand the pathogenesis of human disorders.

In flies, the PNS consists of the large sensory bristles called macrochaetes, which originate from each sensory organ precursor (SOP) cell formed in the larval wing imaginal disc which is the precursor tissue of the adult fly wing and thorax (Bate, 1978).

Our preliminary studies have shown that overexpression of *CtBP* leads to a loss of bristles (Figure 2), whereas weak *CtBP* mutant flies have more bristles (Figure 3). These studies lead us to hypothesize that *CtBP* controls bristle patterning by altering cell fate specification during PNS development. To address our hypothesis, we utilized a genetic approach by studying *CtBP* mutants and observing the phenotypic effects on bristle patterning. We then explored the role of CtBP at a cellular level and observed its effect on cell fate by immunostaining the wing discs with molecular markers.

The results demonstrate that the strong mutant allele of *CtBP* leads to an increase of bristle formation and a change in bristle polarity. Also, as compared to the wild type flies, the strong mutant allele of *CtBP* flies had more SOP cells during PNS development which is consistent with the supernumerous bristle phenotype. From these results, we can conclude that *CtBP* is required to properly establish the patterning of the bristles, and alterations in *CtBP* result in a change in both the number and orientation of the bristles. The absence of *CtBP* increases the number of both SOP cells and bristles.

Question

What role does CtBP play in PNS development? What are the mechanisms by which it controls PNS development?

Results

CtBP is required to properly establish the patterning of the mechanosensory bristles. Alterations in *CtBP* affect both the number and orientation of the bristles. Loss of *CtBP* increases the number of both sensory organ precursor (SOP) cells and bristles, whereas overexpression of *CtBP* decreases the number of both SOP cells and bristles. Therefore, our results suggest that *CtBP* regulates SOP specification during the early stages of PNS development.

Introduction

Drosophila melanogaster (fruit flies) has proven to be an excellent model organism to study development and homeostasis in multicellular vertebrates. One of the molecular mechanisms that is necessary for development is the evolutionary conserved mechanism of transcriptional repression. For this study, we focus on transcriptional corepressor, C-terminal Binding Protein (CtBP) in *Drosophila*, which is highly related to human CtBPs (Hildebrand *et al*, 2002). CtBP does not directly bind to DNA but either directly or indirectly interacts with other transcriptional factors to inhibit transcription.

Recent studies have shown that *Drosophila* CtBP is fundamental for cell-fate specification and embryonic patterning. Studies have proven that *Drosophila* CtBP interacts with other transcriptional repressors, Kruppel, Knirps, and Snail, through the PxDLS peptide motif, to properly establish embryonic patterning (Nibu *et al*, 1998).

Human CtBP was found to interact with the adenovirus E1A oncoprotein through specific amino acid motifs, PxDLS (Schaper *et al*, 1995). When CtBP-mediated repression is altered, a variety of diseases arises including birth defects and cancer. CtBP interacts both indirectly and directly with tumor suppressors, APC (Sierra *et al*, 2006), BRCA1(Yu *et al*, 2006), and RB (Meloni *et al*, 1999), which are responsible for colon cancer, breast cancer, and retinoblastoma, respectively. Therefore, to better understand the pathogenesis of these human disorders, we examined the role that CtBP plays in fruit flies peripheral

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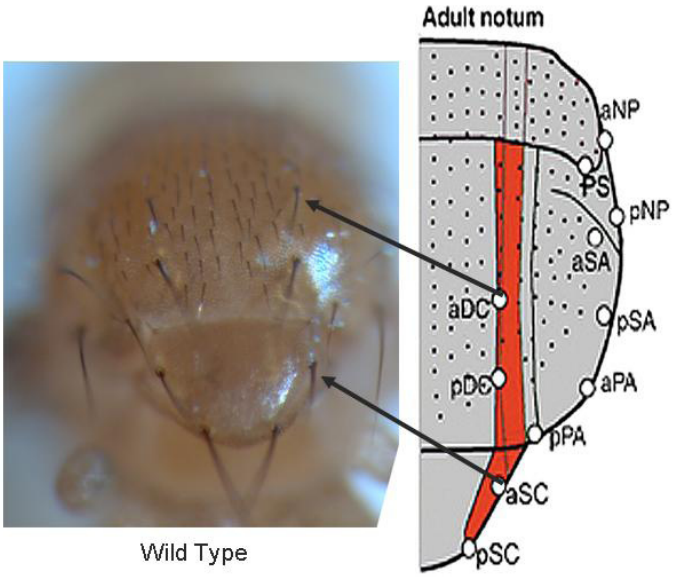


Figure 1: An image of wild-type Drosophila notum where the PNS organs called mechanosensory bristles a.k.a. macrochaetes are shown. These bristles appear in specific location. The arrows indicate where the macrochaetes in the diagram are located on the fly.

nervous system (PNS) development.

The visible structures of *Drosophila* PNS in the dorsal thorax are large sensory bristles called macrochaetes which grow in specific locations. The formation of these bristles is controlled during the development of wing discs at larval and pupal stages. The wing discs are origin of wings and notal structures (Gomez-Skarmeta *et al*, 2003). At larval stages, a cluster of cells called proneural cells form in specific positions in wing discs, and from this cluster, a single or two sensory organ precursor (SOP) cells are chosen. During pupal stages, this SOP cell differentiates into just five cells, the bristle, socket, neuron, sheath, and glial cell after a few cell divisions (Bate, 1978). Therefore, to study PNS development, we looked at bristle patterning.

Our preliminary studies have shown that *CtBP* overexpression leads to a loss of bristles whereas weak mutant alleles of *CtBP* increases bristle formation. These results lead us to hypothesize that *CtBP* controls bristle patterning by altering cell fate during PNS development. Because we had previously studied the effects of a weak mutant allele of *CtBP*, in this study, we examined the effects a strong mutant allele on PNS development *i.e.* bristle formation to elucidate the pathogenesis of human disorders.

Methods and Material:

Drosophila stocks and crosses.

A *yellow, white* (*yw*) fly was used as wild type. A Flippase fly (*yw, hs-flp; Dr/TM3, Sb)* was obtained from the Bloomington Stock center. *yw; FRT82B, Sb, P[w^{+}, y^{+}]/TM3, Ser* was a gift from Eric Lai.

Generation of CtBP mosaic animals

To perform a genetic analysis of *CtBP* using a strong *CtBP* allele (*CtBP$^{87De\text{-}10}$*) in *Drosophila* PNS development, we utilized a genetic strategy called the FLP-FRT method (Golic, 1991) to generate mosaic clones, which is a conditional mutation.. Virgin flies, *yw/yw; FRT82B, CtBP$^{87De\text{-}10}$ / TM3, Sb*, were crossed into males, *yw, hs-flp/Y; FRT82B, Sb, P[w^{+}, y^{+}]/Dr. To generate mosaic clones, embryos from the cross were collected for 1 day, aged for 1 day,* heat-shocked at 37^{o} C for 3 hrs for three consecutive days, and then grown to adults at 25°C. We observed adult female flies with the red-eyed marker (*yw, hs-flp/yw; FRT82B, dCtBP$^{87De\text{-}10}$ / FRT82B, Sb, P[w^{+}, y^{+}]*) and took picture of their bristles under a microscope.

Immunohistochemistry.

Wing imaginal discs were dissected from third instar larvae in phosphate buffered saline (PBS). After a thirty second treatment with a 1:1 mixture of heptane: 4% paraformaldehyde at room temperature, the discs were fixed with 4% paraformaldehyde for 40 minutes at room temperature with rocking. Afterwards the fixative was removed and the discs were washed rigorously with PTX (PBS + 0.1% Triton X-100). Subsequently, the disks were blocked in 5% heat treated Fetal Bovine Serum in PTX either at room temperature for 2 hours or overnight at 4ºC. After removal of supernatant, primary antibody: anti-Achete (purchased from the Hybridoma Bank), anti-Lamin (purchased from the Hybridoma Bank), anti-Senseless, and anti- Green fluorescence protein (GFP) antibody (which company???) in PTX????? was incubated with discs overnight at 4°C. After overnight incubation, the wing discs were washed in PTX for four times to remove background. Secondary antibodies tagged with fluorescent dye were then added, which recognize the primary antibodies, and were incubated at room temperature for two hours. To remove background, wing discs were washed in PTX for four times. The discs were mounted using Vectorshield mounting solution and initially observe under a fluorescent microscope. Images were taken with the confocal microscope.

Confocal microscopy

A LSM 510 Zeiss Laser Confocal (equipped with LSM 510 Meta software) was used for confocal imaging. Projections were created by selecting a Z-series of confocal slices and collapsing them into a single image. All Flouorophores were excited

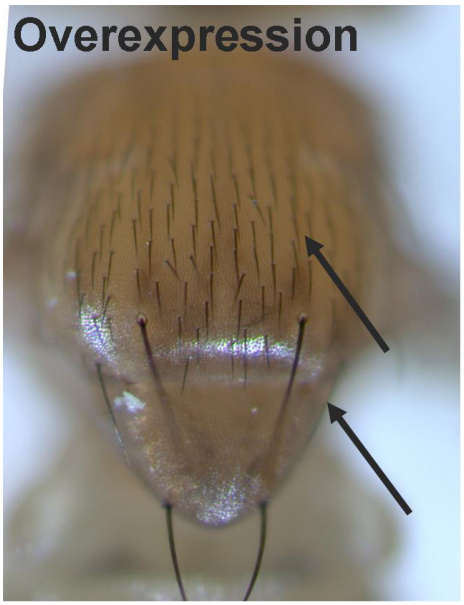


Figure 2: This is an image of an adult notum when CtBP is overexpressed. When CtBP is overexpressed, there is a loss of bristles. As compared to the wild-type fly, the aDC bristle is missing (indicated by the arrow

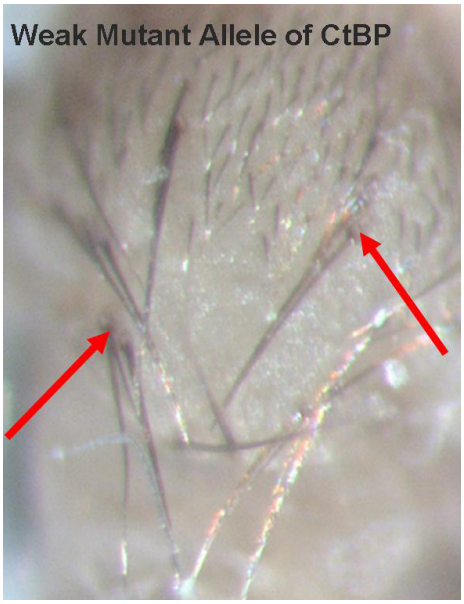


Figure 3: Using a p-element to disrupt the CtBP gene, we constructed a weak CtBP mutant allele and studied its effect on the bristle patterning. (a) wild-type socket (b) weak CtBP mutant allele induces the formation of extra bristles. The arrows indicate the multiple bristles. These flies were dissected out of the pupa cases because they never survive to adult stage.

independently at 488nm (GFP or Alexa 488), at 568nm (Alexa 546 or Cy3) or at 635nm (Cy5); emissions with the following filter sets: 505-550nm, 585-615nm, and 650nm.

Results:

To clarify the figures, long and yellow macrochaetes indicate that the macrochaetes are derived from homozygous *CtBP* mutant cells, whereas short and black macrochaetes are derived from either heterozygous mutant or wild-type cells.

The tables summarize the phenotypic analysis of the strong mutant clones.

Increased bristle formation in CtBP mutants

To examine the role of *CtBP* in *Drosophila* PNS development, we analyzed the genesis of this organ in *CtBP* mutants. Previously, we focused on using a hypomorphic or *CtBP* weak allele, $CtBP^{03463}$. These experiments helped to show that *CtBP* is required to suppress the formation of macrochaetes during PNS development. Such studies demonstrated that most of the sensory organ bristles were duplicated in homozygous for the *CtBP* weak alleles (Fig. 3). We quantified the effect of CtBP mutation on bristle formation. We scored 26 hemi-notums. The results are summarized in Table 2. As shown in this table, the aSC bristle was affected the most (81%), which was consistent with our images because at the aSC bristle, there were two instead of one bristle (figure 3a and 3c).

To further understand the role of *CtBP,* we utilized a null mutant allele. Unfortunately, the embryonic lethality associated with this allele precludes us from studying later stages of fly development. To circumvent this problem, we employed the FLP-FRT method to generate mitotic clones which lack *CtBP*. Because only small patches of *CtBP* mutant cells are induced in an otherwise heterozygous animal, this permits the analysis of *CtBP* at stages after the zygotic mutant lethal stage of development. The results of this experiment are summarized in Table 1. In wild-type flies, there were 14 visible macrochaetes (figure 1), but when *CtBP* was mutated, an extra bristle appeared in the adult flies' notum (figure 4). After analysis of many flies, we discovered that the DC macrochaetes were the most affected (69%) in heterozygous cells for the *dCtBP* mutation (table 1). Another phenotypic effect due to mutating CtBP (Table 1) was most of the extra bristles that formed were derived from heterozygous CtBP cells. This suggests that there was a threshold in which the level of *CtBP* expression was inadequate to properly establish bristle patterning.

As compared to a wild-type notum region that exhibited a single bristle housed in a single socket, in the strong mutant *CtBP* mutant strain, there were two short black macrochaetes, derived from heterozygous *CtBP* cells, growing out of one socket (figure 5). These results indicated that haploid insufficiency of the CtBP strong allele on bristle formation and CtBP is required for proper formation of bristles.

In summary as shown in Table 1, bristle patterning is disrupted when *CtBP* is mutated. These phenotypic analyses agreed with our previous findings that a partial loss of function of *CtBP* led to extra macrochaetes formation.

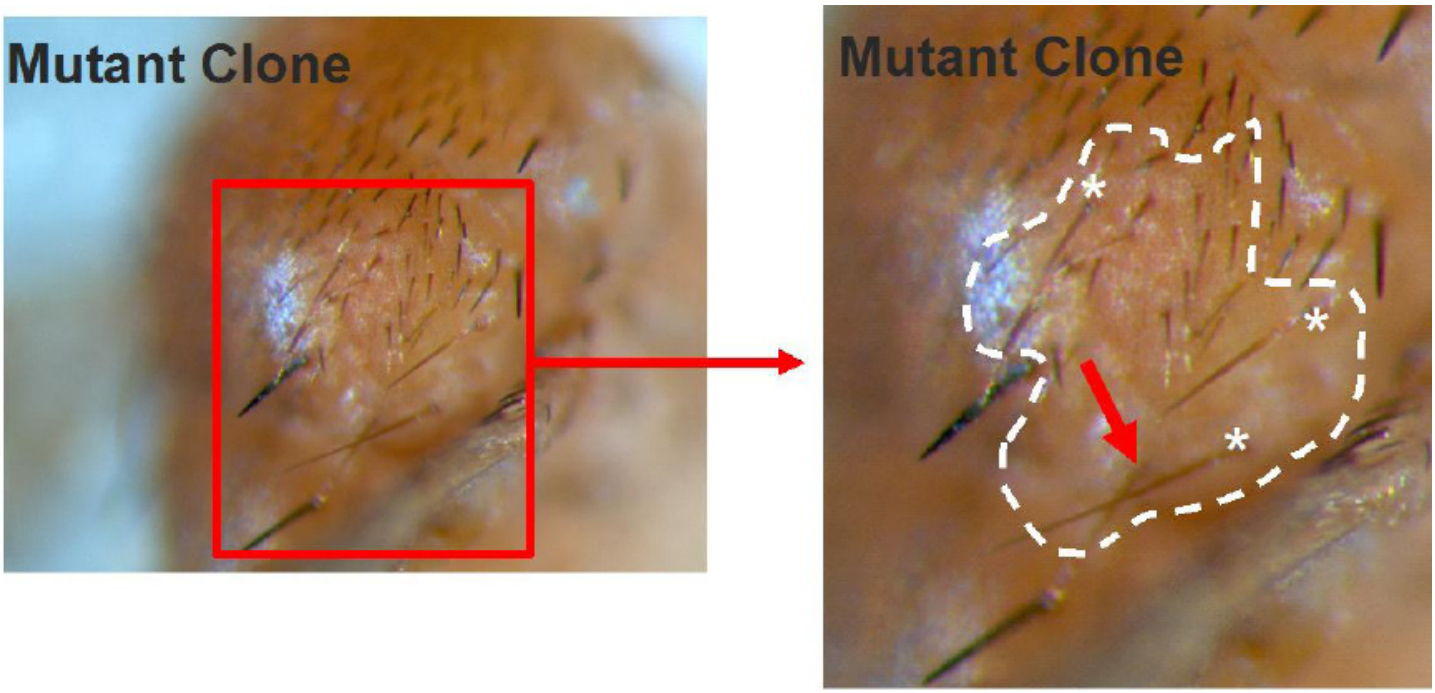


Figure 4: An image of a CtBP mutant clone. When CtBP is mutated, it leads to the formation of extra macrochaetes. The long, yellow macrochaetes indicate that the macrochaetes are derived from homozygous CtBP mutant cells. The dotted region indicates the boundary between the heterozygous and mutant region and the red arrow indicates where there is an extra macrochaetes. The stars indicate the long, yellow macrochaetes that are located in the normal location.

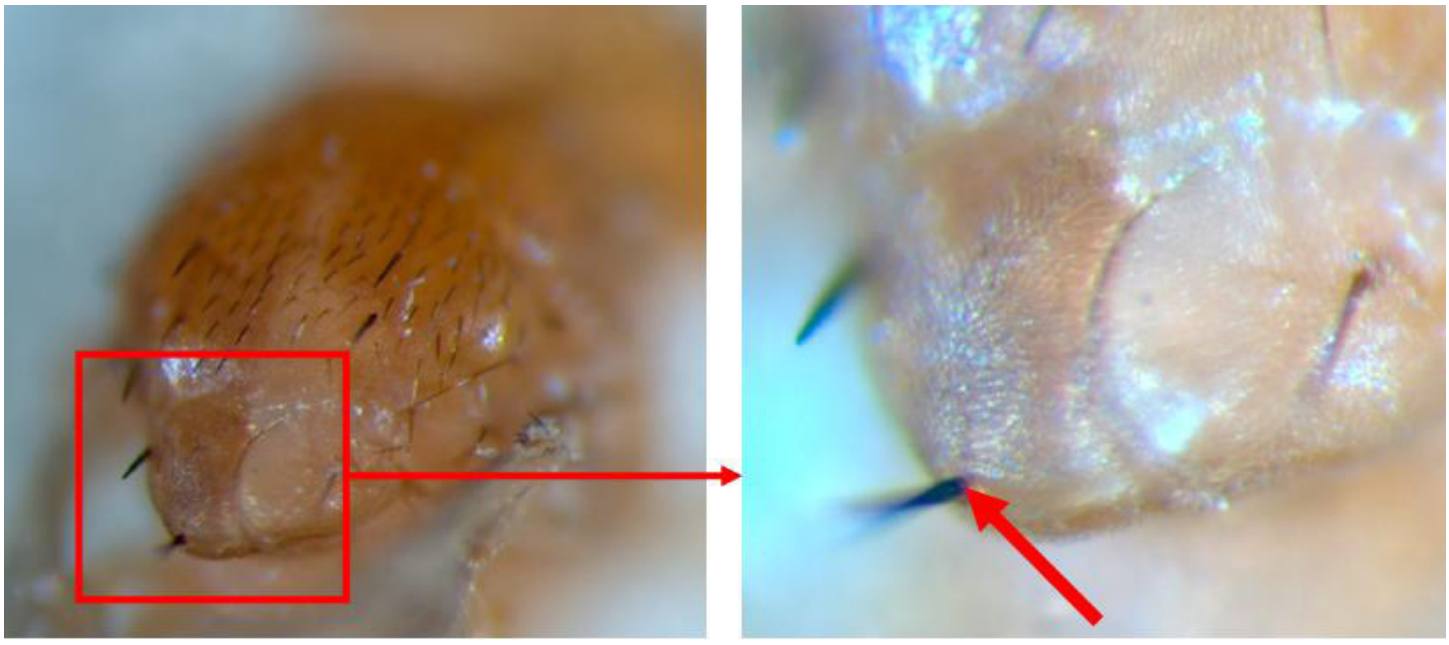
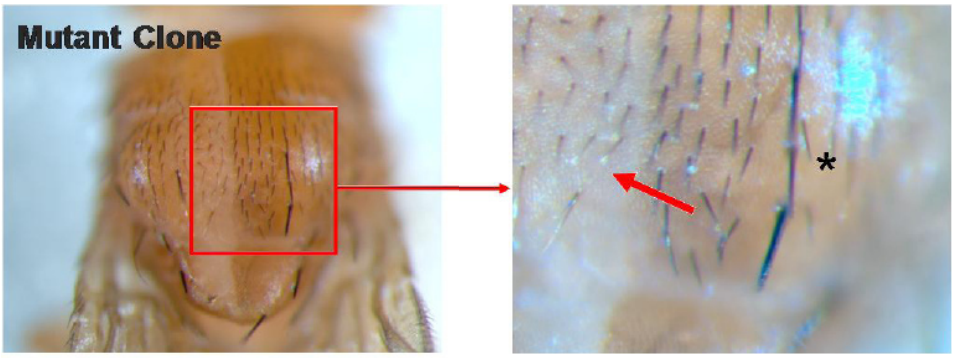


Figure 5: This is an image of a strong mutant CtBP allele. The arrow indicates where there are two macrochaetes appearing out of one socket.

Clearly, these results demonstrate that CtBP plays an important role in bristle patterning i.e. PNS development.

CtBP negatively regulates SOP cell formation

In order to understand how CtBP affects bristle formation, we analyzed formation of SOPs in larval wing discs. *CtBP* clones in wing discs were negatively marked by GFP expression, since we used the EGFP gene located *in trans* to the *CtBP* mutant chromosome, instead of using the white and yellow genes. Wing discs from larva after heatshock were then immunostained with Senseless antibody. Senseless is a zinc finger transcription factor which has been shown to be specifically expressed in newly emerged SOP cells (Jafar-Nejad,



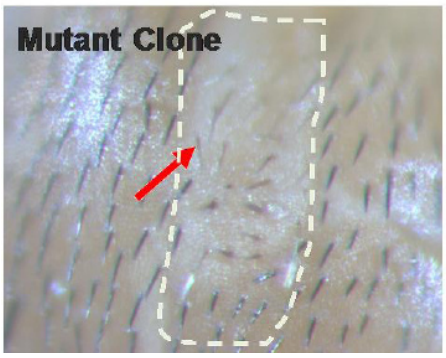


Figure 6: This is an image of a mosaic clone. The star indicates the extra heterozygote bristle between the aDC and pDC bristles. The enclosed dotted region illustrates the defect in bristle polarity in mutant CtBP mosaic region. Normally, bristles orientate posterially but the bristles in the mosaic region orientate randomly. This shows that CtBP is not only involved in bristle formation but also in bristle planar-polarity.

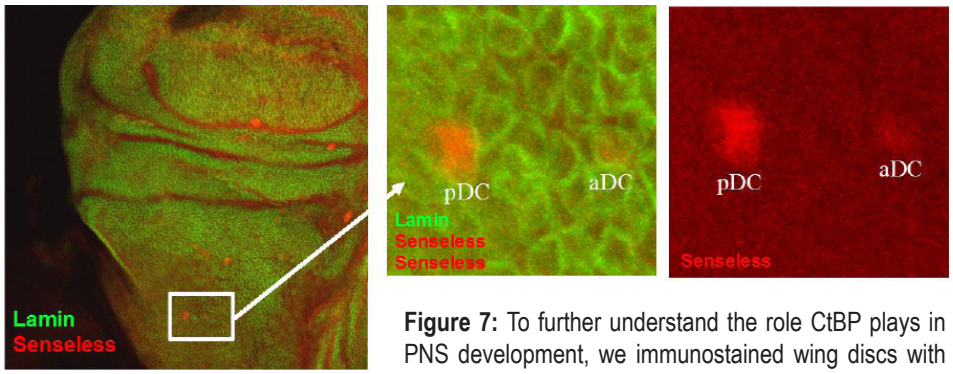


Figure 7: To further understand the role CtBP plays in PNS development, we immunostained wing discs with antibodies against specific cell-fate markers. Confocal micrograph showing SOP cells in a wing imaginal disk. The red fluorescence (Sens) marks the SOP cell and the green fluorescence (Lamin) marks the nuclear envelope. In figure 7b, there are two SOP cells, aDC and pDC, and these cells will give rise to the aDC and pDC bristles, respectively.

2003). In wild-type wing discs, two SOP cells were visible (figure 7), but in strong *CtBP* mutants where green fluorescence was absent, there were three visible SOP cells (figure 8). These SOP cells are individual cells because the lamin (a nuclear marker) stain enclosed the senseless stain (figure 8b). This result was consistent with our bristle analysis of the *CtBP* mutant clones (data not shown), because two of the SOP cells would give rise to the aDC and pDC and the extra SOP cell would give rise to the extra bristle. This result suggests that CtBP negatively regulates SOP specification during the early stages of PNS development and that the extra bristles may be derived from ectopically formed SOP cells.

CtBP overexpression leads to a loss of SOP cells

In our preliminary studies, we used the UAS-Gal4 system to overexpress *CtBP* and observed the phenotypic effects on bristle patterning. Shown in figure 2, overexpression leads to a loss of bristles. Therefore, to examine if the loss of bristle was due to a loss of SOP cell formation during development, we immunostained *CtBP* overexpression wing discs. As shown in figure 9, the aDC SOP cell was missing. This is consistent with our preliminary results because in figure 2, the aDC bristle is missing. Therefore, these results further support that CtBP plays a role in SOP cell formation during PNS development.

Complete loss of CtBP function leads to a defect in bristle planar-polarity

Cells' ability to orientate bristles correctly is essential for the PNS to function properly. In wild-type flies, all macrochaetes and microchaetes pointed posterially, but in *CtBP* mutant clones, both large and small bristles were orientated in random directions (figure 6). This result demonstrates that an upset of *CtBP* led to a change in bristle polarity.

CtBP-mediated polarity defects are not associated with abnormal Armadillo *subcellular localization.*

Armadillo is a protein that is involved in the signaling pathway (Wingless or Wnt) necessary to establish planar polarity (Bajpal et al, 2003). To examine whether the defect in bristle polarity is due to a disruption of this signaling pathway, we tested if loss of *CtBP* function in the larval wing discs affected the subcellular localization of Armadillo in the wing disc epithelial cells. Direct comparison of *CtBP* mutant and heterozygous cells showed that the Armadillo protein was unaltered in the mutant cells (figure 10). This finding demonstrates that CtBP does not appear to be working through a known downstream effector but rather through an unknown mechanism.

Discussion:

Our results indicate that the absence of *CtBP* increases the number of both sensory organ precursor (SOP) cells and that this leads to more bristles. From this we can conclude that *CtBP* mutants increase the expression of senseless and dictates more proneural

cells to become SOP cells. Therefore, CtBP plays a fundamental role in bristle development by negatively regulating SOP cells. Conversely, when this same SOP marker was examined in a CtBP overexpression background we found a corresponding decrease in the number of senseless stained cells in the wing discs.

Future Directions:

During early wing disc development, proneural clusters express *achete* and *scute* genes (Skeath J. et al, 1991). These proneural clusters consist of a group of cells that all have the potential to become a SOP cell that expresses senseless. To examine how extra SOP cells are formed when CtBP is reduced, we tried to monitor the expression levels of the Acheate protein in the wing discs. Unfortunately, we were unable to successfully stain the discs for this protein. In the future, we have to optimize conditions for anti-Achete immunostaining by utilizing different strategies. to understand the molecular cascade of CtBP. Does CtBP act on proneural cells to regulate the downstream process of SOP formation?

Fortunately, we have shown that *CtBP* mutants have an increase number of SOP cells from Sensless immunostain. From this, we can suggest that *CtBP* mutant increase the expression of *senseless* and dictates more proneural cells to become SOP cells. Therefore, CtBP plays a fundamental role in bristle development by inhibiting proneural cells from becoming SOP cells.

These findings suggest how CtBP functions in humans. Previous studies have shown that the absence of CtBP leads to birth defeats and cancer. From our research, we can suggest that human CtBP represses normal somatic cells from becoming immortal cells (cancerous cells) similar to how *Drosophila* CtBP represses proneural cells from differentiating into SOP cells.

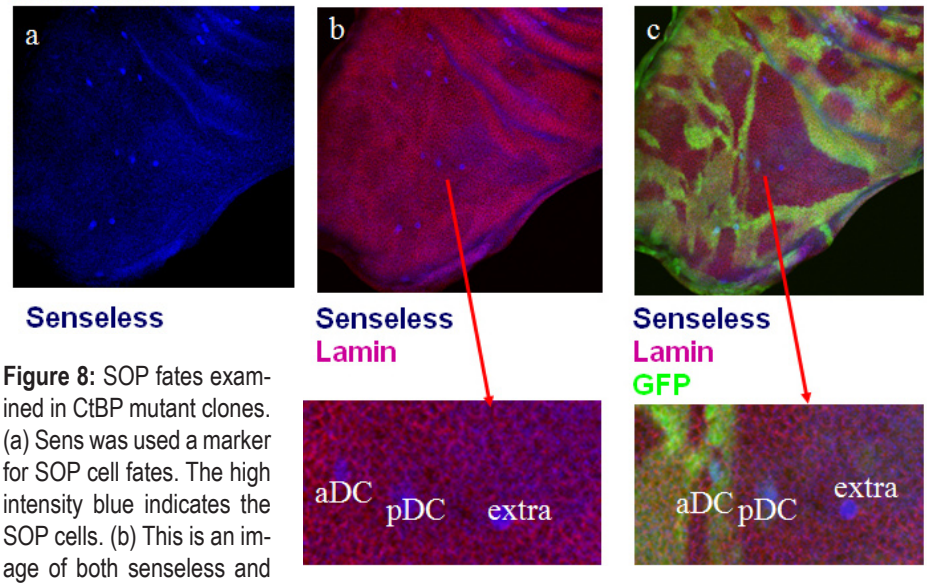


Figure 8: SOP fates examined in CtBP mutant clones. (a) Sens was used a marker for SOP cell fates. The high intensity blue indicates the SOP cells. (b) This is an image of both senseless and lamin immunostaining. (c) GFP expression was used to negatively mark the CtBP mutant clones (i.e., a lack of GFP indicates a CtBP mutant cell). There are three SOP cells instead of two SOP cells. Two of the three SOP cells will give rise to the DC bristles and the other SOP cell will give rise to the extra bristle.

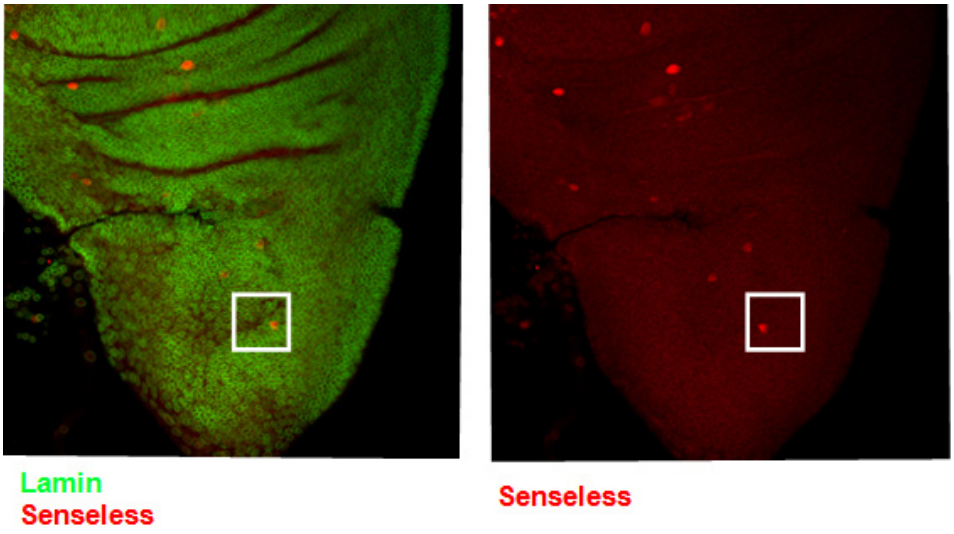


Figure 9: In our preliminary studies, we overexpressed CtBP and observed bristle formation. We found that overexpression of CtBP leads to a loss of bristles. To examine whether the loss of bristle is due to a loss of SOP cells, overexpressed CtBP fly's wing discs were immunostained with lamin and senseless. These figures indicate that when CtBP is overexpressed, only one, instead of two, SOP cell forms. This single SOP cell, indicated by the box, will give rise to the pDC.

The mechanism in which CtBP controls bristle polarity is currently unknown. Our preliminary studies demonstrate that CtBP loss-of-function does not alter Armadillo expression, a protein that is known to operate in planar cell polarity signaling pathways. A cell's ability to know where to orientate the bristle is fundamental for the PNS to properly function. Since planar cell polarity is such an important pathway we intend to better understand the involvement of CtBP during this process. For example, to be able to hear properly, ear hair cells must be oriented across the sensory epithelium in the same direction (Hawkins RD et al, 2004). All in all, we want to further explore the mechanism in which CtBP disrupt bristle polarity because we have

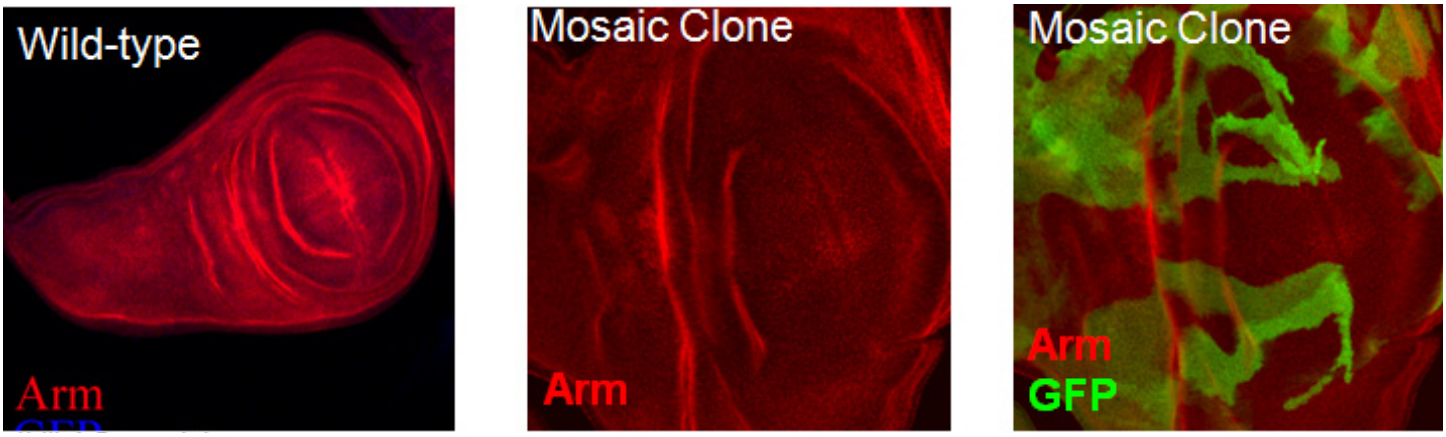


Figure 10: When CtBP is mutated, it leads to a defect in bristle polarity. Armadillo is a protein that mediates the wingless, which is a protein that setups planar-polarity. To test whether CtBP controls armadillo expression to determine planar-polarity, CtBP mutant wing discs were immunostained with anti-armadillo antibodies. As shown in these figures, there is no difference in armadillo immunostaining between a wild-type and mutant clone wing discs. GFP indicates where CtBP is present.

LOCATION OF EXTRA BRISTLE				
	Quantity		Percentage (%)	
DC Region	**26**		**69**	
Type of Cell in which Bristles are derived	*CtBP* Mutant	Heterozygous	*CtBP* Mutant	Heterozygous
	3	23	12	88
SC Region	**9**		**23**	
Type of Cell in which Bristles are derived	*CtBP* Mutant	Heterozygous	*CtBP* Mutant	Heterozygous
	4	5	44	56
NP Region	**1**		**3**	
Type of Cell in which Bristles are derived	*CtBP* Mutant	Heterozygous	*CtBP* Mutant	Heterozygous
	1	0	100	0
PA Region	**2**		**5**	
Type of Cell in which Bristles are derived	*CtBP* Mutant	Heterozygous	*CtBP* Mutant	Heterozygous
	0	2	0	100
Total Extra Bristle	**38**		**100%**	

Table 1: This table shows the number of extra bristle formed out of the 64 semi adult notums we analyzed. Double bristles, which are two bristles coming out of one socket were also counted. Percentage was calculated by dividing the quantity into the total number of extra bristles formed CtBP mutant indicates that the bristle was derived from a homozygous CtBP mutant cell. These bristles were long and yellow bristles. Heterozygous indicates that the bristles were derived from heterozygous CtBP celsl and these bristles are short and black. Percentage of these bristles were calculated by dividing the number of extra type (i.e. CtBP mutant or heterozygous) of bristles into the total number of extra bristles in that particular region.

LOCATION OF EXTRA BRISTLE IN WEAK *CtBP* MUTANTS		
	Quantity	Percentage (%)
ASC Region	21	58
ADC Region	7	19
PPA Region	5	14
APA Region	3	9
Total Extra Bristle	36	100

Table 2: This table shows the number of extra macrochaetes formed out of the 26 semi-mosaic adult notums we analyzed. Other macrochaete regions that are not included in the table indicate that there were no extra bristles. Percentage was calculated by dividing the quantity into the total number of extra bristles formed.

superficial knowledge of what controls planar-polarity.

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The Greatest Conflict of Interest: Caen, June 6 – 7, 1944

Michael Anderson[1]

Caen, France, was an unassuming Norman town situated along the Orne River, six miles inland of what would become Juno Beach. Since June, 1940, it had suffered under the scourge of Nazi occupation, and by 1944, the vast majority of its inhabitants prayed daily for liberation. They could not imagine, though, the horror that lay before them: the Allies would bring the freedom for which the Caennais yearned, but only after one of the most devastating aerial bombardments of the Second World War.

By those Caennais who resented the German occupation, the bombings brought by the Allied advance were accepted as a worthy price to pay for freedom; however, they did not want to see their city decimated, their loved ones taken from them, and their lives destroyed in a sudden eruption of smoke and flame. To successfully invade and liberate France, however, the Allies needed to conquer Caen – a vital communications and transportation hub of the Normandy region. They therefore deemed imperative the use of wide-scale bombings to destroy German morale and drive the Nazis from the town. Yet, the relentless bombardments risked alienating the Caennais and the larger French populace, whose support would be essential to the success of the invasion and to the reconstruction of a democratic France. This study is a transnational examination of the emergence and evolution of these dilemmas, and contributes significant historical scholarship to relatively unexplored areas of both military and socio-cultural history.

Introduction[1]

By the summer of 1944, the Allied position in the war had improved dramatically. The United Nations dominated both the sea and the air. The Western Allies had successfully invaded and liberated North Africa, and were slowly marching up the Italian peninsula. On the Eastern Front, the Soviet Red Army was achieving great success. The entire Allied war effort now turned on Operation Overlord, the invasion of Europe. At the center of that invasion lay the unlikely city of Caen.

Caen, France, was an unassuming Norman town situated along the Orne River, six miles inland of what would become Juno Beach. As a transportation and communications hub of the Normandy region, however, it was a city of vital strategic interest for the Allies. Not only was Caen a gateway into France, but it was also a strategic 'choke point' where Allied forces could block German reinforcements and supplies moving to the invasion beaches. Furthermore, by driving the Germans from the city and its environs, the Allies could secure the plateaus to the south and southeast, opening important airfields for subsequent operations. Most importantly, the city was the hinge about which the entire Normandy campaign would pivot. Allied commanders planned the capture of Caen by Anglo-Canadian forces on the afternoon of June 6, 1944, the first day of the invasion. By July 1, the Allied armies would then swing around to face eastward and begin the drive on Germany.[2] Caen was a D-Day objective of the utmost importance, and therefore became a primary target of Anglo-American bombardiers.[3] Yet, the decision to bomb the city created and exposed divisions within the Allied camp and the social fabric of the town.

The Allied Predicament

In Great Britain and the United States, political concerns clashed violently with strategic military calculations. Indicative of these disputes were the debates over the Transportation Plan – the pre-invasion bombing campaign designed to destroy the rail system in Normandy. Civilian leaders perceived French assistance to be paramount to the success of D-Day operations. While Resistance fighters would supply the Allies with vital intelligence on bombing targets and German emplacements and movement, non-collaborationist French citizens formerly inactive in the Resistance but emboldened by the landing would sabotage German communications, transportation, and operations.[4] Winston Churchill and the British War Cabinet feared air raids would jeopardize this assistance, for "the fact that scores of thousands of French civilians […] would lose their lives or be injured […] might be held to be an act of very great severity, bringing much hatred."[5] Therefore, the Prime Minister and his political allies asserted, commanders must ensure that the military advantages accrued from the bombings outweighed the political drawbacks.

Furthermore, the anger stirred within the French population risked paving the way for the westward spread of Communism. As Foreign Secretary in Churchill's government, Anthony Eden was keenly aware of the bipolar dynamic emerging in the international arena, and was acute to circumstances that could threaten Britain's future geopolitical position in relation to the Soviet Union. For him, this was the very problem created by the Transportation Plan: excessive bombing of large civilian centers "would affect our position in France […] *vis-à-vis* Russia and would handicap us in re-establishing our relations with these countries after the war."[6] The attacks prescribed by the plan would aggravate the French people, who would in turn look toward the Russians for post-war assistance. This would permit the expansion of the Communist sphere of influence into Western Europe.

Humanitarian concerns, too, collided with military interests. Though in favor of the pre-invasion air interdiction campaign, Arthur Tedder, an RAF Air Chief Marshal and the Allied Deputy Supreme Commander, was wary of destroying whole cities simply in order to block enemy traffic moving through them. In fact, Tedder was so adamant in his opposition to

[1]Duke University

the projected bombing of Caen that he fought to have the plan rescinded until the very day on which it was implemented.[7] Despite his misgivings, the majority of Allied commanders supported the plans.

Backed by President Franklin D. Roosevelt, military commanders were generally less sympathetic to these political and humanitarian concerns. While short- and long-term geopolitical considerations were undoubtedly significant, they were not of primary importance. In a surprisingly stern letter to Churchill on April 5, 1944, General Dwight D. Eisenhower stressed that

> one of the fundamental factors leading to the decision for undertaking OVERLORD was the conviction that our overpowering air force would make feasible an operation which might otherwise be considered extremely hazardous, if not foolhardy.[8]

From the perspective of Eisenhower and his military advisors, the Transportation Plan and post-invasion air raids on Caen would greatly facilitate Allied operations and improve the probability of victory. To ignore such assets in favor of maintaining positive French opinion would be a travesty. That an April 4, 1944 Joint Intelligence Subcommittee report indicated that the bombings of railway targets would not have "any great effect on our position in France […] *vis-à-vis* Russia" further solidified the conviction that victory in Europe was the unreserved top priority.[9]

Furthermore, Allied commanders were willing to risk French civilian lives in order to achieve their objectives. Among the most adamant, in fact, was a Caennais: Major General Marie-Pierre Koenig, commander of the French Forces of the Interior.[10] "'This is War,'" he exclaimed, "'and it must be expected that people will be killed. We [the French] would take twice the anticipated loss to be rid of the Germans.'"[11] In the end, military interests prevailed, and the bombings that were to open the Allied entry into Caen were authorized.

Caen: June 6-7, 1944

In the early hours of June 6, the Caennais awoke to explosions along the coast and to the thunderous drone of thousands of Anglo-American aircraft. Initially, the attacks were dismissed as yet another inconsequential air raid; however, as the bombardments continued, the significance of the moment became clear. As the violence crept inland, initial euphoria was replaced by a harsh reality. After a failed early-morning mission, 9:00 AM witnessed the first significant bombardment of Caen, an attack that lasted no less than forty minutes. Caught largely unprepared, confusion and chaos consumed the population.[12] Parents frantically gathered their children and headed for the basement. Others cowered under staircases, tables, and heavy furniture. Fearing their homes would collapse above them, some dug trenches in their backyards to shield them from the attacks. Irrespective of personal circumstances, all were affected by these bombings. The bedridden were driven from their homes. Crying infants were forced to endure terrifying events they could not understand. The rich and destitute suffered equally. None knew what to do or where to find safety.

Exhausted, the Caennais got a brief reprieve at 1:00 PM. The morning's events had been tumultuous, but the absence of Allied bombers provided a hope for a rapid liberation. In this atmosphere, family and friends sat down for lunch, ignorant of what lay before them. At 1:30 PM the waves of RAF heavy bombers returned. A mere twenty minutes later, the city-center was razed and fires ignited by the attacks raged throughout the city. One incendiary at Vaucelles, a suburb of Caen, burned continuously until June 18, nearly two weeks after the initial attacks.[13] Twice more – at 4:25 PM and 10:00 PM – the city was attacked. In the end, 1,250 Halifaxes and Lancasters unleashed thousands of tons of bombs on the unsuspecting and largely unprepared city below, a miserable situation compounded by the naval shelling from the Allied fleet moored off the Norman coast.[14] At 2:40 AM the following day, the town received its worst bombardment yet. Caen was being destroyed by the very forces sent to free it, and while the city's inhabitants were devastated by these attacks, German entrenchments were little affected. Ironically, the Nazis found the ruins to be more easily defensible than the intact city, while the Anglo-Canadian forces were hindered by the large craters and piles of rubble their bombs created.

French Reactions

Prior to the invasion, a number of conflicting interests created fissures within the social fabric of Caen. The Nazi presence became increasingly burdensome, as regulations were more strictly enforced, arrests, deportations, and executions more frequent, requisitions more common, and daily necessities scarcer. That Caen, "'a city eminently French, perhaps more French than many others because it radiates a real personality throughout its History," was forced to conform to the sterile life of German military rule made the occupation increasingly suffocating.[15] Consequently, great numbers of Caennais looked to the Allies for deliverance. As one young girl remembered, the "presence of this army had become intolerable to us. […] And it [was] with joy, that we awaited D-Day."[16]

Many non-collaborationist Caennais, however, were reticent to accept outright the destruction that would accompany an Allied reentry. The Caennais knew that their close proximity to potential landing beaches and their strategic significance would place them directly in the crosshairs of Allied bombsights. Evincing the predicament, one candid French woman wrote in her poem,

[W]e hope the English arrive,
That they chase away forever the sinister oppressor;
But, an anguishing dilemma our desolation kindles,
Our friends for a time will be our aggressors.[17]

To most, the occupation was untenable, but the loss of their city, their family, and their livelihood was likewise

unacceptable. Unfortunately, the events of the war had proven the impossibility of deliverance without significant costs. The Caennais were thus faced with a terrible dilemma.

Hence, not only did the bombings of June 6 – 7 fracture the architecture of an ancient French city, but by exacerbating these conflicting interests, they also further polarized an already divided people. Indeed, the wide range of sentiments expressed in reaction to the attacks formed a continuum that reflected the dilemmas permeating French society at the time. Many welcomed the invaders and accepted their plight as a necessary evil. In one telling example, a dying civilian lamented that "I will never see the liberation that I awaited for so long, but I know that by my death, others will be liberated. Long live France. Long live the Allies."[18] For observers like this victim, the devastation wrought by the bombings was a worthy price to pay, for regardless of the present circumstances, the attacks signaled the return of freedom and dignity to France.

Aghast at the destruction, others found it difficult to reconcile the freedom that would purportedly accompany an Allied advance with the utter devastation that was preceding it. Some were skeptical that the liberation truly outweighed the costs. These concerns only worsened when the Caennais awoke on June 7 to discover that the swift liberation for which so many had dreamt had not been effected. Instead, the carpet-bombings would continue. Describing the 3:00 PM air raid that day, Ernest Noel-Dubuisson succinctly captures the tension of the moment: "Bombardment of the city that is consumed by fire. The sky is nothing but an immense red glow. […] Life is no longer tenable."[19] Such sentiments betray the conflicting interests that plagued the Caennais, predicaments that would follow these general trends throughout the siege.

Allied Reactions

Across the Channel, the dilemmas proved equally divisive. Unlike the debates surrounding the pre- and post-invasion bombing plans, however, humanitarian concerns were superseded by purely military issues. Caen had not been seized, and the front was freezing. If the deadlock was not broken, the Allies would be vulnerable to German counteroffensives that could threaten their initial foothold on the Continent. Interestingly, geopolitical concerns also remained prevalent, but had changed radically. No longer fearful of the effects of Allied action on the political landscape of post-war France, Churchill, Eden, and their supporters were now concerned with *inaction* in Normandy. If the invaders were stalled, the door would be left open for a Soviet liberation of France and the subsequent expansion of the Communist sphere of influence. All measures to achieve victory must therefore be employed. Hence, the devastating bombardments of Caen were met with little opposition in the Allied camp.

The dilemmas that did emerge centered on the proper use of air power in unfreezing the front. In a June 14 meeting at Montgomery's Normandy headquarters, RAF Air Chief Marshal Trafford Leigh-Mallory offered heavy bombers – typically used for less-precise, long-range bombings – in close-air support of ground forces. With Tedder leading the opposition, the proposition sparked a wave of debate that divided the Air Commanders. Especially in its close-air support missions, Allied air power was often a hindrance to friendly armies. Accidental casualties among Allied forces were not uncommon, and as a veteran commander of the North African campaign and the invasion of Sicily, Tedder was keen to these shortcomings. Consequently, he was wary of Leigh-Mallory's desires. Though the proposition was quickly rebuffed, it signaled yet another divisive conflict of interest that emerged as a direct result of the situation in Caen. In fact, Leigh-Mallory was so enraged by the opposition to his plan that he nearly resigned his command in protest.[20] Similar to the French reactions, these dilemmas would pervade Allied decision-making throughout the Battle of Caen.

Caen was liberated on July 19, 1944. Much of the city had been destroyed and approximately 5,800 civilians, nearly a full one-tenth of the population, had perished.[21] However, the conquest of Caen came so late that it bore little impact on the overall war effort. Not only was an eventual Allied victory in Normandy already certain, but the communication and transportation networks that had given the city such a vital strategic importance had long since been destroyed. That the fall of Caen gave the Allies control of the highlands of the Bourguébus Ridge and the airfields of the Caen-Falaise Plain to the south and southeast of the city somewhat legitimated the siege and undoubtedly facilitated the ensuing campaign. The conquest of the actual city, however, was a rather hollow victory.[22]

Conclusions

The decision to bomb Caen engendered conflicting interests that tormented French civilians and Allied political and military leaders. While the French dilemmas throughout the ordeal followed patterns that had emerged well before the invasion, the Allied conflicts that arose during the siege departed from those that had framed the pre-invasion debates. Furthermore, Caen's military significance had waned by July, making the eventual capture of the city a rather insignificant event in the greater campaign. Nonetheless, the liberation of Caen mended some of the schisms that had been created, particularly those fracturing French society. The vast majority of Caennais now welcomed the Anglo-Canadian troops. After all, these soldiers had incurred great costs to return the freedom for which so many Caennais yearned. When the process of rebuilding structures and lives began, this initial appreciation was frequently replaced by tension and animosity. Thus, while the liberation united France and the Allied nations, the widespread damage left behind undoubtedly contributed to the years of post-war resentment and the soured Cold War relations between the two.

Endnotes

1 I would like to thank Professor Michael Allsep for his dedication to this project, his untiring efforts, and his unwavering patience that have helped turn a dream into a reality. I

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2 Brown David. "The Bombing of Caen, 6 June to 18 July 1944." *L'Année '44, les libérateurs*. International Symposium, March 4-5, 1994. Caen: Edition du Lys, 1994: 95.

3 These bombings targeted bridges spanning the Orne River, which if destroyed would impede German reinforcements from reaching the front and from strengthening the defensive lines in the city.

4 File 381 (4-24-43), Section 4. Combined Intelligence Committee. "German Capabilities to Oppose a Cross-Channel Invasion in the Spring of 1944." May 16, 1943. Record Group 218. Box 316. National Archives Building II, College Park, Maryland, 1943: 3-4.

5 Churchill Sir Winston S. *The Second World War: Closing the Ring*. Vol V. Boston: Houghton Mifflin Company, 1951. 6 Vols: 528.

6 Eden Anthony. *The Reckoning*. Boston: Houghton Mifflin Company, 1965: 521

7 Brown 1994: 96-8

8 Chandler, Jr. Alfred D., Ed. *The Papers of Dwight David Eisenhower, the War Years: III*. Vol III. Baltimore: Johns Hopkins Press, 1970. 5 Vols: 1809. It was also noted that the estimates of the number of civilian casualties was overstated and based on a number of false premises. See, for instance, RAF Air Marshal Charles Portal's objections in Tedder Lord Arthur. *With Prejudice: The War Memoirs of Marshal of the Royal Air Force Lord Tedder*. London: Cassell and Company, Ltd., 1966: 523-4. See also Eisenhower's objections in Chandler, Jr. 1970: 1809.

9 File 373.11 (5-12-44). Joint Intelligence Subcommittee. "French and Belgian Reactions to Bombing of Railway Targets." April 4, 1944. Record Group 218. Box 292. National Archives Building II, College Park, Maryland, 1944: 3.

10 The French Forces of the Interior was the Resistance-army in occupied France.

11 Koenig, as cited in File 373.11 (5-12-44). War Department. Declassified Message. May 17, 1944. Record Group 218. Box 292. National Archives Building II, College Park, Maryland, 1944.

12 At 8:00 AM and 8:30 AM, Allied pilots dropped leaflets over the city, warning inhabitants of the impending danger and encouraging them to evacuate. Few heeded the warnings. Angot Cécile. "Les Caennais dans la bataille de Caen, mai-septembre 1944." Diss. Université de Caen. 1996: 51-2.

13 Plichard Odile. "Le Bon Sauveur de Caen et la Seconde Guerre Mondiale." Diss. Université de Caen, Faculté de Médecine, 1981: 96.

14 *Les Larmes de la liberté*. Film. In collaboration with Le Mémorial de Caen. France 3 Normandie, 1994: 0:04.1 – 0:04.6.

15 Elizabeth Creed, as cited in Angot 1996: 3. Translated from the French: "[…] une ville éminemment française, peut-être plus française que beaucoup d'autres car elle dégage une réelle personnalité tout le long de son Histoire." Translation is my own.

16 Témoignage de Lucienne Sonnet Rullier. "Ma vie en cet été 44." TE 685. Mémorial de la Paix à Caen. Caen, France: 3. Translated from the French: "[…] la présence de cette armée nous devenait insupportable. […] Et c'[était] avec joie, que nous attendions ce jour 'J.'" Translation is my own.

17 Hélène Bernard-Martin, as cited in Angot 1996: 49. Translated from the French: "[… N]ous avons espoir que les Anglais arrivent, / Qu'ils chassent à jamais le sinistre oppresseur; / Mais, dilemme angoissant que nos chagrins avivent, / Nos amis pour un temps seront nos agresseurs." Translation is my own.

18 *Les larmes de la liberté* 1994: 0:05.56 – 0:06.8. Translated from the French: "[…] je ne verrai jamais cette libération que j'ai tant attendu, mais je sais que par ma mort, d'autres seront libérés. Vive la France. Vive les Alliés." Translation is my own.

19 Témoignage d'Ernest Noel-Dubuisson. "Débarquement, 1944." TE 505. Mémorial de la Paix à Caen. Caen, France: 2. Translated from the French: "Bombardement de la ville qui est en feu. Le ciel n'est qu'une immense lueur rouge. […] La vie n'est plus tenable." Translation is my own.

20 D'Este, Carlo. *Decision in Normandy*. New York: E. P. Dutton, Inc., 1983: 225-8

21 Boivin, Michel. *Les Victimes civiles de Basse-Normandie dans la Bataille de Normandie*. Centre de Recherche d'Histoire Quantative. Caen: Editions-diffusion du Lys, 1996: vii.

22 D'Este 1983: 318

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