

# UCSB McNair Scholars Research Journal



UNIVERSITY OF CALIFORNIA, SANTA BARBARA  
2014 Volume 4

**UCSB McNair Scholars  
Research Journal**

**University of California, Santa Barbara  
2014 – Volume 4**

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# UCSB McNair Scholars

## Research Journal

2014 - Volume 4

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## **Letter from Interim Executive Vice Chancellor Joel Michaelsen**

It gives me great pleasure to welcome you to Volume IV of the UCSB McNair Scholars Research Journal. This journal recognizes the research accomplishments of a select group of eight undergraduate scholars from a wide range of disciplines. These students have successfully completed our McNair Scholars Program. Their contributions to this journal represent the hard work and intellectual creativity of students that we anticipate – indeed have every confidence -- will ultimately be leaders in their respective fields, and faculty mentors who exemplify the dedication of our campus to undergraduate success.

Named after Dr. Ronald E. McNair Jr., physicist and NASA astronaut, the UCSB McNair Scholars Program is geared to provide research opportunities for first-generation college, low-income, and underrepresented undergraduates as a means of preparing them for graduate school. Our McNair Scholars Program aligns with our campus goals of improving both the diversity and quality of our students, and preparing them for success beyond their undergraduate experience. By combining undergraduate research with faculty mentoring and academic support services, the McNair Scholars Program provides a path to graduate school for students from families that may not have traditionally considered even an undergraduate college education.

We're very proud of the success of our McNair Scholars Program and this dedicated collection of students that have completed the program and produced scholarship for publication. I congratulate the McNair Scholars, applaud the faculty mentors, and extend my appreciation to the staff of the McNair Scholars Program for their dedication and work in helping these students achieve success.

With warm regards,

Joel Michaelsen  
Interim Executive Vice Chancellor

## **Letter from College of Letters and Sciences Executive Dean Melvin L. Oliver**

Welcome to the fourth issue of the UCSB McNair Scholars Research Journal. The work of the eight scholars in this journal represents the fruits of an apprenticeship relationship that they shared with a faculty mentor to better understand and learn to carry out research in their respective fields of specialization. The research they have produced represents the result of applying creative ideas to research questions using systematic and rigorous methods of established research protocols in several areas, ranging from the social sciences to mathematics and engineering. I am certain you will agree with me that this research is both impressive and engaging.

The UCSB McNair Scholars were encouraged to advance their education in hopes that they will become the next generation of college and university professors. We have seen scholars in previous cohorts go on to prestigious graduate and professional schools and we have no doubt that, as a consequence of their McNair experience, these scholars too will excel in their graduate program. As first generation, and often underrepresented minorities, they are an important resource for higher education as our student population becomes more diverse and our nation's productivity becomes increasingly reliant on the academic, economic and social success of this multiethnic mosaic.

I salute the Director, Dr. Beth Schneider, the Assistant Director, Monique Limón, Program Coordinator Micaela Morgan, Writing Consultant Dr. Ellen Broidy, staff, graduate mentors, and the array of faculty mentors who have selflessly given of their time, for creating the kind of supportive and nurturing environment that has made the production of this journal possible. And finally, I want to

salute the McNair scholar authors who, I hope, will look fondly upon this publication as one of their first in a long line of research publications in a stellar academic career!

Sincerely,

Melvin L. Oliver  
Executive Dean, College of Letters and Sciences &  
SAGE Sara Miller McCune Dean of Social Sciences

## **Letter from McNair Program Director, Dr. Beth E. Schneider**

Volume IV of the UCSB McNair Scholars Program is now in the hands of our students, alumni, faculty mentors, campus allies, and McNair colleagues around the country. As the Director of the McNair Scholars Program since its inception, it is a pleasure to showcase the work of some of our students.

These eight scholars and authors spent 18 months or more with the UCSB McNair Scholars Program. Expectations are high for the UCSB McNair scholars, and each of these students met them, presenting their faculty-mentored scholarship at one McNair Scholars National Research Conference as well as offering at least two poster sessions in various academic venues. Among this current group of authors are five seniors who applied to graduate school this academic year; all are going fully funded to graduate school in Fall 2014 (University of Missouri, University of Texas, University of Illinois, Michigan State University, Ball State University).

The papers published in Volume IV are the final versions of manuscripts our graduates were willing to see through to publication. They went the extra mile, writing and rewriting in response to a steady stream of comments from their mentors and the journal editors. As undergraduate research papers, we expect that these publications will be the first of many manuscripts published by these eight students during their graduate training and in their first academic positions.

The perseverance, patience, and diligence displayed by the scholars will serve them well as they continue with professional training in their respective fields. For all first-generation, low income, and underrepresented undergraduates, the existence of the journal and the labor it represents will hopefully be an inspiration

to seek research opportunities, develop successful mentorships, and take seriously a future in which the McNair Scholars Program played and continues to play an important part.

The UCSB McNair Scholars Program is supported by the Office of the Executive Vice Chancellor and the Deans of the College of Letters and Sciences and the College of Engineering. We are grateful to our campus administrators for their continued support of our work. Our science, technology, engineering, and mathematics (STEM) scholars are also being funded in 2014 by Edison International.

Special thanks to the UCSB McNair Scholars staff, and congratulations to the scholars.

Beth E. Schneider  
Professor of Sociology  
Director, McNair Scholars Program

**Letter from the Editors,  
Drs. Ellen Broidy and Beth E. Schneider**

The McNair Scholars Program at UCSB is pleased to bring you the fourth volume of the UCSB McNair Scholars Research Journal. A cooperative effort of faculty mentors, McNair staff, and most especially a dedicated cadre of student scholars, the journal represents months of research, writing, editing and reviewing on the part of all the participants.

For our scholars, preparation of their manuscripts for publication in the Journal began as a challenging puzzle and ended as a rewarding experience. Novices when they started the process, the scholars embarked on a year-long adventure in what it takes to produce academic work suitable for publication. With good humor and extraordinary patience and fortitude, they experienced the frustration of being asked to revise and revise again and then the feeling of elation that comes with a final acceptance. Through this process, the McNair staff was able to provide scholars with a practical hands-on introduction to the types of writing and revision expected of graduate students and academics.

Submission to the Journal was never a requirement of participation in the UCSB McNair Scholars Program so we were enormously gratified that a number of our students representing the class of 2014 as well as scholars graduating in 2015 decided to allow their work to be put under the editorial microscope. Previous publication arrangements with faculty mentors meant that some scholars were unable to submit their work. The scholars who did contribute worked diligently on their papers, rethinking, rewriting, reorganizing, and in some instances, reconceptualizing core ideas. We applaud them all for their hard work and commitment. We want to say a special thank you to the faculty mentors who worked

alongside the students to guide them in the production of work of such high caliber.

We trust that you will enjoy reading the work of the UCSB McNair Scholars represented in this fourth volume of the Journal. We look forward to bringing you the voices of new generations of scholars in subsequent volumes and thank you on behalf of the authors, mentors, and editors who made this publication possible.

Best,

Ellen Broidy

Writing Consultant, UCSB McNair Scholars Program

Beth E. Schneider

Professor, Department of Sociology

Director, UCSB McNair Scholars Program



# Substance Use among Young Latino Men

Nathan I. Alamillo

Mentor: Dr. Victor M. Rios  
Department of Sociology

## Abstract

*Although studies suggest Latinos have elevated rates of drug-related problems, research has not focused on the way parental and peer relationships influence perceptions about alcohol, marijuana, and tobacco or how parents and peers influence drug-using behavior among young Latino<sup>1</sup> men.<sup>2</sup> In order to address this gap in the literature, this study uses a mixed-method approach by surveying and interviewing 10 Latino males between the ages of 18 and 25 participating in a community-based program for at-promise<sup>3</sup> young men living in Santa Barbara, California. Through*

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<sup>1</sup> In this paper I use the terms “Latino” and “Hispanic” to refer to people of Latin American and Spanish-speaking origin or ancestry. While there is controversy regarding the use of these terms, the literature included in this study uses both terms to refer to people of Spanish-speaking ancestry living in North, Central, and South America. I keep the original term used in each study, but I only use the term “Latino” when referring to the participants in this study.

<sup>2</sup> This study focuses on young Latino men, but some of the studies report findings from Hispanics and Latinas/os without differentiating by sex or gender. As such, the research studies reflect findings from Hispanic and Latino males and females, unless otherwise noted.

<sup>3</sup> Sociologist Victor Rios defines youth “at-promise” as “those youth who have traditionally been labeled ‘at-risk’—youth who lived in marginalized conditions” (2011:176). The reason he refers to this population as “at-promise” rather than “at-risk” is that the former label is associated with positive connotations while the latter perpetuates stigmatization and criminalization. The

*questionnaires and in-depth interviews, this study found that alcohol and marijuana use was prevalent among the participants, and many of them began using these drugs early in their teenage years. Preliminary results indicate that many of the participants engaged in binge drinking and driving under the influence of alcohol. Most of the participants associated with friends who used alcohol, marijuana, and tobacco regularly. Conversely, only alcohol use was common among the participants' family members; parental communication about substance use was not common. There was an association between parental support (i.e. parental communication and family cohesion) and parental control (i.e. parental monitoring and parental permissiveness) and the participants' alcohol and marijuana use. Another important finding was that abuse and dependence rates were high for alcohol and marijuana, but not for tobacco.*

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idea is that youth will be treated as individuals worthy of opportunities rather than “risks” to be avoided.

## Introduction

Substance misuse is a major health and social problem among many young adults in the United States. Binge drinking<sup>4</sup> in particular is associated with a range of health problems such as acute myocardial infarction (heart attack), sexually transmitted infections (STIs), unintended pregnancies, hypertension, gastritis, pancreatitis, meningitis, unintentional injuries, alcohol poisoning, and motor vehicle crashes (Brewer and Swahn 2005; Naimi et al. 2003). Motor vehicle crashes, in particular, are the primary cause of alcohol-related deaths in the United States (Brewer and Swahn 2005; Centers for Disease Control and Prevention 2004). Indeed, excessive alcohol use is the third leading cause of preventable deaths in the United States, and more than half of those deaths are attributable to binge drinking (Kanny, Liu, and Brewer 2011). High-risk<sup>5</sup> alcohol use is especially problematic because more than half of all alcohol consumed by adults occurs during episodes of binge drinking behavior (Brewer and Swahn 2005). There is evidence that Hispanic adults are more likely to binge drink than other ethnic/racial groups in the United States (Substance Abuse and Mental Health Services Administration 2011; Naimi et al. 2003).

Problematic marijuana use behavior is difficult to measure because a dependable definition of high-risk marijuana use has not yet been established. According to the National Institute on Drug Abuse (NIDA 2002/2010), marijuana impairs short-term memory, attention, judgment, coordination, and balance—factors that can potentially impair an individual’s ability to drive. Since marijuana

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<sup>4</sup> According to the National Institute on Alcohol Abuse and Alcoholism (NIAAA 2011), binge drinking is a pattern of drinking that brings a person’s blood alcohol concentration above 0.08. For males, binge drinking usually results from drinking 5 or more alcoholic drinks in a two-hour period.

<sup>5</sup> “High-risk” substance use in this paper refers to using alcohol, marijuana, and tobacco in a manner that is likely to lead to drug-related problems, including driving under the influence of alcohol, substance abuse, and substance dependence. I use the terms “drug(s)” and “substance(s)” interchangeably to refer to the use of alcohol, marijuana, and/or tobacco, unless otherwise noted.

smoke contains more carcinogens than tobacco, there is also limited evidence that marijuana increases the risk of certain cancers (mainly the lungs and other parts of the respiratory tract), chronic cough, bronchitis, and even heart attack (NIDA 2002/2010). Moreover, marijuana was responsible for 4.2 out of 7 million Americans who were dependent on or abusing illicit drugs in 2008 (NIDA 2002/2010).

Driving under the influence of drugs is one of the most health-compromising behaviors that people can engage in. There is some evidence that higher levels of blood-THC concentrations increase the risk of driving impairment,<sup>6</sup> though to a lesser degree than alcohol impairment, and that combining alcohol with cannabis produces an additive effect (Bramness, Khlabani, and Morland 2010). After alcohol, marijuana is the most frequently found substance among intoxicated drivers involved in automobile accidents (Calabria et al. 2010; Richer and Bergeron 2009). One study found that 6.8% of drivers who were involved in automobile accidents were under the influence of THC, and that 21% of these marijuana-intoxicated drivers were also above the legal limit for driving under the influence of alcohol (NIDA 2002/2010). Conversely, other studies have failed to confirm the relationship between marijuana-related impairment and traffic accidents, since drivers under the influence of marijuana may compensate by being more alert, cautious, and driving at a slower speed (Bramness et al. 2010). As the public debate about the direct and indirect effects of marijuana on morbidity and mortality rates continues, marijuana remains the most widely used illicit<sup>7</sup> drug in the United States (SAMHSA 2011; NIDA 2002/2010).

Tobacco use is also a major public health concern that is linked to numerous short-term and long-term diseases. Tobacco

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<sup>6</sup> Studies show that THC impairs driving skills by impairing short-term memory, attention span, reaction time, and coordination (Richer and Bergeron 2009).

<sup>7</sup> According to the National Survey on Drug Use and Health, “illicit drugs include marijuana/hashish, cocaine (including crack), heroin, hallucinogens, inhalants, or prescription-type psychotherapeutics (pain relievers, tranquilizers, stimulants, and sedatives) used non-medically” (SAMHSA 2011).

has been found to cause emphysema, cerebrovascular diseases, chronic bronchitis, and heart disease, while also increasing the risk of acquiring numerous cancers<sup>8</sup> (Vidrine, Reitzel, and Wetter 2009). In fact, it is estimated that tobacco is responsible for one third of all cancer deaths and 87% of lung cancer deaths, making it the leading cause of preventable deaths and diseases in the United States (CDC 2009; Vidrine et al. 2009; Mokdad et al. 2004). Although tobacco use is less prevalent among Latinos than non-Latino whites, the former is more likely than the latter to be diagnosed with lung cancer at an advanced stage (Vidrine et al. 2009; Wisnivesky et al. 2005), less likely to receive cessation advice (Vidrine et al. 2009; American Legacy Foundation 2007), less likely to use nicotine replacement therapy (Vidrine et al. 2009; American Legacy Foundation 2007), less likely to quit smoking successfully (American Legacy Foundation 2007), less likely to undergo surgical treatment (Vidrine et al. 2009; Wisnivesky et al. 2005), and less likely to survive cancer (Vidrine et al. 2009). Additionally, tobacco is linked to half of the 10 leading causes of death among Hispanics/Latinos: heart disease, cancer, stroke, birth defects, and chronic respiratory diseases (Vidrine et al. 2009; American Legacy Foundation 2007; Mokdad et al. 2004).

The prevalence of high-risk substance use among young Hispanic men is worth assessing since Hispanics are the largest and fastest growing ethnic minority group in the United States, making up 16% of the total U.S. population (Passel and Cohn 2008; Grant et al. 2004). Projections are that by 2025 Latinos will make up 25% of the total population in the United States, with the majority being of Mexican descent (Passel and Cohn 2008; Prado et al. 2009; Grant et al. 2004). It is important to address substance-related issues among young Latinos not only because they will compose a substantial portion of the United States population in the near future but also because reducing drug-related problems

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<sup>8</sup> Tobacco increases the risk of developing cancer in the nasopharynx, nasal cavity, paranasal sinuses, lip, oral cavity, pharynx, larynx, lung, esophagus, uterine cervix, kidney, bladder, stomach, and acute myeloid leukemia (Vidrine et al. 2009).

will have a positive effect on the larger population. Understanding the ways in which familial, peer, and sociocultural factors shape drug norms among young Latino men is crucial for the development of effective intervention programs that decrease beliefs associated with high-risk substance use behaviors among this population.

## **Literature Review**

### ***Substance Use among Young Adults, Hispanics/Latinos, and Men***

Although using drugs such as alcohol, marijuana, and tobacco is only one of many behaviors that can be detrimental to health, these three substances in particular are associated with the four leading causes of death among young people ages 10 to 24: motor vehicle crashes, unintentional injuries, homicide, and suicide (CDC 2012). The relationship between substance use and unfavorable health outcomes is alarming considering the prevalence of alcohol, marijuana, and tobacco use among young adults. According to the National Survey on Drug Use and Health, about 60% of adults between the ages of 18 and 25 used alcohol, 18.5% used marijuana, and 39.5% used tobacco in the month prior to the survey (SAMHSA 2011). This study also showed that adults between the ages of 18 and 25 had the highest rates of illicit drug use, tobacco use, substance abuse and dependence, binge drinking, and driving under the influence of alcohol and illicit drugs, compared to adolescents ages 12-17 and adults older than 25 years of age. Other studies show that binge drinking is highest among young men between the ages of 18 and 24, and decreases with age (Kanny et al. 2009; Chen, Dufour, and Yi 2003). These statistics indicate that problematic substance use behavior is common among many young adults.

Extensive research conducted on young adults shows the disparity in rates of substance use among different racial and ethnic groups in the United States. Research suggests that Latinos are affected at disproportionate rates by a number of substance-related problems. For example, young Hispanic males have been shown to

have high rates of problematic drinking behavior (Mills and Caetano 2010), including binge drinking (SAMHSA 2011; Naimi et al. 2003), driving under the influence of alcohol (Caetano, Ramisetty-Mikler, and Rodriguez 2008), and substance abuse or dependence (SAMHSA 2011). It is important to assess the prevalence of substance-related problems among Latinos because they are significantly less likely to have health insurance than African Americans and non-Latino whites (Vidrine et al. 2009). As a result, Latinos that experience health problems caused or worsened by their substance use are not as likely as other ethnic/racial groups to receive medical care. For example, a study conducted by the National Institute on Alcoholism and Alcohol Abuse found that Hispanics reported lower rates of alcohol dependence than Whites, but the former were less likely to seek treatment than the latter (NIAAA 2011). Failure to receive proper treatment may exacerbate preexisting illnesses and health conditions among young Latino men, thus putting them at risk for premature death.

Within the Latino population, men are disproportionately affected by a number of substance-related problems. Adult Hispanic men are more likely than Hispanic women to engage in health-compromising behaviors such as binge drinking and driving under the influence of alcohol (Caetano, Ramisetty-Mikler, and Rodriguez 2009; Caetano et al. 2008; Naimi et al. 2003). Hispanic men also consistently report higher rates of substance abuse and dependence than their female counterparts (Caetano et al. 2009; Caetano et al. 2008). Furthermore, lung cancer is the leading cause of cancer-related deaths among Hispanic men and second leading cause of cancer-related deaths among Hispanic women (Wisnivesky et al. 2005). This may be due to the fact that Hispanic men living in the United States smoke tobacco at twice the rates of Hispanic women (American Legacy Foundation 2007; Foraker et al. 2004). Foraker et al. (2004) found that that tobacco use was similar among adult Latinos (24.7%), adult white men (26.3%), and adult white women (22.8%), but significantly lower among adult Latinas (11.9%). As such, Latinos are three times as likely to

die from lung cancer, and twice as likely to die from coronary heart disease as Latinas—diseases that are associated with tobacco use (Foraker et al. 2004).

### ***Individual and Sociocultural Influences***

In order to reduce the prevalence of high-risk substance use among young Latinos, it is crucial to understand how different individual and sociocultural factors affect their decisions to engage in these behaviors. Extensive, empirical research has explored the ways in which individual factors influence substance use among young Hispanics/Latinos in the United States. Some of the factors associated with problematic substance use among young Latinos include receiving bad grades in school (Parsai et al. 2009; Voisine et al. 2008), having children (Vega et al. 1998), having positive attitudes towards drugs (Fisher et al. 2007), having an early onset of alcohol use (King and Vidourek 2010; Hingson, Heeren, and Winter 2006), and having a history of substance abuse and dependence (Blanco et al. 2007). Other factors associated with increased substance use among Latinos include experiencing stressful life events (Simantov, Schoen, and Klein 2000) and feeling hopeless (Griffin et al. 2004; Simantov et al. 2000). Stressful life events and feeling hopeless in particular may lead to using drugs to cope with negative emotions, which has also been associated with problematic drug use. In a four-factor model study on Black and White adolescents, Cooper (1994) found that “enhancement,” “social,” and “coping” motives for drinking alcohol were all associated with heavy drinking, but only the latter motive was linked to drinking problems.

Equally important are the sociocultural factors that shape beliefs and behaviors regarding substance use among Latino youth. Research suggests that parenting practices influence Hispanic adolescents’ perceptions about alcohol, marijuana, and tobacco in various ways. For example, some studies indicate that low parental monitoring (Kosterman et al. 2000; Parsai et al. 2009) and parental permissiveness (Parsai et al. 2009) are associated with increased likelihood of using drugs. Other studies indicate that parents can

shield their children from using drugs by being supportive (Simantov et al. 2000), being proactive (Kosterman et al. 2000), and having strong anti-drug norms (Voisine et al. 2008). Furthermore, young boys may feel that using drugs is acceptable if their parents do not communicate with them and set clear expectations against substance use (Lac et al. 2011; King and Vidourek 2010; Foley et al. 2004).

As adolescents get older, peers play a significant role in the way young people perceive drug use. Peer influences are especially important among Hispanics born in the United States because they are more likely than their foreign-born counterparts to have friends who use drugs and are more likely to use drugs themselves (Prado et al. 2009). One study found that Mexican American adolescents who associated with drug-using peers were more likely than those whose peers did not use drugs to report weaker antidrug personal norms, stronger intentions to use alcohol, marijuana, and tobacco, and higher rates of using these three substances (Parsai et al. 2009). Another study found that associating with peers that use alcohol, marijuana, and tobacco was related to recent alcohol use among Hispanic youth (King and Vidourek 2010).

It is clear from the research that there are various individual and sociocultural factors that help shape perceptions about alcohol, marijuana, and tobacco among Latino youth. Less is known about the ways in which family and friends shape beliefs, motives, and behaviors regarding alcohol, marijuana, and tobacco use among young Latino adults. The present study seeks to address this gap in the literature. This study posits four main hypotheses based on prevailing empirical findings:

***Hypothesis 1:*** Lower levels of parental support and parental control will be associated with using alcohol, marijuana, and tobacco at an early age and in higher frequency.

***Hypothesis 2:*** Perceived frequent peer and family use of alcohol, marijuana, and tobacco will be associated with positive beliefs about the use of these drugs.

***Hypothesis 3:*** Positive beliefs about drug use will be associated with engaging in high-risk substance use behaviors (e.g. driving under the influence of alcohol and other drugs).

***Hypothesis 4:*** Using alcohol, marijuana, and tobacco to cope with negative emotions will be associated with experiencing problems caused or worsened by using these substances (e.g. substance abuse).

## **Methods**

The sample consisted of 10 Latino young adults between the ages of 18 to 25 living in Santa Barbara, California. I collected data through questionnaires and semi-structured interviews. I also engaged in ethnographic fieldwork by following them around the neighborhood in order to observe daily stressors they encountered and to develop a better understanding of their views and behaviors. Entrée had already been established from a larger research project conducted by Dr. Victor Rios on processes of crime and desistance among gang-associated youths. The goal of Dr. Rios' project was to understand what young men thought about gangs, crime, violence, and drug use in their community.

The participants were part of a purposive sample since they were recruited from a community-based program that aimed to divert youth away from the juvenile and criminal justice systems and guide them into the education system. Intervention strategies included focus group discussions, interactive presentations, and team-building workshops that emphasized personal, educational, and professional development. Since many of the young men were involved in routine activities that made them prone to antisocial behavior, Rios and his research assistants created and implemented a curriculum to expose them to constructive opportunities and help them engage in didactic experiences. Furthermore, the young men were connected to resources and services in the community, and, when appropriate, they received assistance in securing employment and enrolling at the local community college.

Some of the young men had criminal records and had been labeled “gang members” by local law enforcement prior to and while participating in the program. Although some of the participants were associated with gangs, I did not seek to confirm gang membership as my project is on alcohol, marijuana, and tobacco use among young Latino men “at-promise”—not on gangs. More important than gang affiliation was the fact that all of the young men had previous experiences with the juvenile and criminal justice systems via encounters with law enforcement (police and probation officers) and institutionalization in corrections facilities (juvenile hall and county jail). Consequently, the beliefs and behaviors reported by the participants are not representative of all Latinos in their neighborhood.

There are several characteristics regarding the demographic setting of this study that are worth mentioning. According to the U.S. Census Bureau (2010), Santa Barbara has a population of over 88,000 residents, 55% White and 38% Latino. Even though there are more Whites than Latinos living in this city, there are more Latino families living in poverty. In 2008, one quarter of Latinos were living in poverty, compared to only 10% of Whites (U.S. Census Bureau 2009). In Santa Barbara County, Latinos comprise 43% of the population yet only make two-thirds the median household income of non-Hispanic white households—\$46,274 for Latino households compared to \$69,286 for non-Hispanic white households (County of Santa Barbara 2013). In addition, while Hispanic high school graduation rates are on the rise, they still represent the racial group with the highest dropout rates, with 15% of Hispanics between the ages of 16 and 24 leaving school without a high school credential (National Center for Education Statistics 2012). Preliminary findings from the larger study conducted by Dr. Rios show that Latino high school students in this city have an average grade point average (GPA) of 2.6, compared to white students with an average GPA of 3.6. Perhaps not surprisingly, many of the young Latino men in this study were raised in families that faced socioeconomic and educational marginalization.

## **Questionnaire Measurements**

Participants were asked demographic questions regarding their age, gender, ethnicity/race, educational attainment, employment status, and their household living arrangement. The subjects were also asked at what age they began using alcohol, marijuana, and tobacco as well as how frequently they used these three substances per week. I distributed, collected, and analyzed all of the questionnaires under the direction of Dr. Rios.

Drug-related perceptions measured by the questionnaire included perceived drug risk, perceived drug harm, and perceived peer and family drug use. All of the responses for this section ranged from 1 to 4, with higher scores indicating more positive perception about each drug than lower scores. *Perceived drug harm*<sup>9</sup> was measured based on the extent to which respondents believed the use of alcohol, marijuana, and tobacco would be harmful for someone their age. I asked the participants three questions (one for each drug), with responses varying from 1 (very harmful) to 4 (not harmful at all).

*Perceived drug acceptability* was measured by asking participants how acceptable they believed the use of each drug was for people their age. The scale was scored from 1 (never acceptable) to 4 (always acceptable).

*Perceived peer and family drug use* was assessed with six questions regarding the regular use of alcohol, marijuana, and tobacco among their relatives and friends. The participants' responses varied from 1 (none) to 4 (most of them).

The items used to measure *parental support* were influenced by the definition provided by Barnes et al. (2006): "parental behaviors toward the child... which convey to the child

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<sup>9</sup> The questions for perceived drug harm was influenced by the National Survey on Drug Use and Health, which assessed *perceived drug risk* by asking respondents "how much they thought people risk harming themselves physically and in other ways when they use various substances in certain amounts or frequencies" (NIAAA 2011).

that she or he is valued and loved.” Drawing from other studies, parental support was measured with eight questions regarding family cohesion<sup>10</sup> and parental communication. For *family cohesion*, I asked participants to what extent they agreed or disagreed with the following three statements, with responses varying from 1 (strongly agree) to 4 (strongly disagree):

- “I like to spend time with my family.”
- “I am very close to my family.”
- “My family is supportive.”

For *parental communication*,<sup>11</sup> I asked participants to what extent they agreed or disagreed with the following five questions, with responses varying from 1 (very often) to 4 (never):

- “How often do you talk to your parents about what’s on your mind?”
- “How often do you ask your parents for advice?”
- “How often do you talk to your parents about alcohol?”
- “How often do you talk to your parents about marijuana?”
- “How often do you talk to your parents about tobacco?”

The items used to measure **parental control** were influenced by the definition provided by Barnes et al. (2006): “parental behaviors towards the child that are intended to direct the child’s behavior in a manner acceptable to the parent.” Drawing from other studies, parental control was measured with two

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<sup>10</sup> The questions for *family cohesion* were influenced by two studies: Lac et al. (2011) and Olson, Portner, and Bell (1992). Olson and colleagues (1992) defined family cohesion as “the emotional bonding that family members have toward one another.”

<sup>11</sup> The first two questions for *parental communication* were drawn from Lac et al. (2011). I conceptualized the last three questions with the intent to gauge parental communication specifically about alcohol, marijuana, and tobacco.

questions regarding parental monitoring<sup>12</sup> and four questions regarding parental permissiveness.<sup>13</sup> For *parental monitoring*, I asked participants the following questions, with responses ranging from 1 (very often) to 4 (not often):

- “When you leave the house, how often do your parents ask where you are going?”
- “How often do your parents know where you really are?”

For *parental permissiveness*, I asked the following questions, with responses varying from 1 (not often) to 4 (very often):

- “How often do your parents let you go out whenever you want?”
- “How often do your parents let you drink alcohol?”
- “How often do your parents let you smoke marijuana?”
- “How often do your parents let you smoke tobacco?”

*Parental and peer relationships* were assessed using the Inventory for Parental and Peer Attachment (IPPA) originally developed in 1987 by Armsden and Greenberg, and later modified into an unpublished measure that separately assessed perceived attachment to mothers, fathers, and peers. I asked participants a total of 75 questions to gauge the quality of their relationship with their mothers, fathers, and close friends along three dimensions: trust, communication, and alienation. All three sets of questions were essentially the same with only minor changes to address the statements to their mother, father, or close friends. The responses varied from 1 (almost never or never true) to 5 (almost always or always true).

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<sup>12</sup> The first question was drawn from Parsai et al. (2009), and the second question was drawn from Lac et al. (2011).

<sup>13</sup> The first of these questions was drawn from Parsai et al. (2009). I conceptualized the last three questions to measure the extent to which participants believed their parents tolerated their use of alcohol, marijuana, and tobacco.

*Motives for using alcohol, marijuana, and tobacco* were assessed using the Drinking Motives Questionnaire-Revised developed by Cooper (1994), in which four motives were linked to alcohol use: coping, social, enhancement, and conformity.<sup>14</sup> I asked participants 20 questions (five from each motive) to determine how often they used alcohol, marijuana, and tobacco for the four motives, with options varying from 1 (never) to 6 (almost always).

### *Interview Measurements*

I asked the young men general questions about their educational and/or employment status, household living situation, experiences with the juvenile and criminal justice systems, and their relationship with their friends and family members. If participants had children, I asked them additional questions about their experiences as fathers and how these experiences influenced the decisions they made. I also asked them questions about their experiences with alcohol, marijuana, and tobacco: age of initiation, frequency of drug use, with whom they use the drug, benefits and consequences they experience as a result of their drug use. I conducted, transcribed, and coded all of the interviews under the direction of Dr. Rios.

Substance use perceptions were measured based on the participants' beliefs about using alcohol, marijuana, and tobacco. I asked participants similar questions for each of the three drugs.<sup>15</sup>

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<sup>14</sup> Cooper's (1994) four-factor model posits that there are four different motives for using alcohol. "Social" motives involve "externally generated, positive reinforcements" (for social rewards). The "enhancement" motive deals with "internally generated, positive reinforcement" (to elevate mood or well-being). The "conformity" motive entails "externally generated, negative reinforcement" (to avoid social rejecting). Lastly, "coping" is an "internally generated, negative reinforcement" (to reduce negative emotions).

<sup>15</sup> The questions for alcohol perceptions and tobacco perceptions were the same as for marijuana perceptions, substituting the words "alcohol" and "tobacco" for "marijuana" for their respective set of questions.

For example, *marijuana beliefs* was assessed with the following four questions:

- “How acceptable is it for someone your age to smoke marijuana?”<sup>16</sup>
- “How harmful is it for someone your age to smoke marijuana?”
- “Do you think smoking marijuana increases the chances of getting into trouble?”
- “Do you think marijuana is addicting?”

For the first question, participants were considered to have positive beliefs if they said that the use of the drug was “usually acceptable” or “always acceptable.” Additionally, answering “somewhat harmful” or “not harmful at all” for the second question implied positive beliefs. For the third and fourth questions, answering “no” indicated positive beliefs.

For *alcohol beliefs*, respondents were asked one additional question:

- “How many alcoholic drinks can you consume in a two-hour period before your ability to drive becomes impaired?”

Participants that said it would take six or more drinks to impair their ability to drive were considered to have positive beliefs about alcohol. According to the National Institute on Alcoholism and Alcohol Abuse (2011), consuming about five alcoholic drinks in a two-hour period generally brings men’s blood alcohol concentration (BAC) level to 0.08% or more, which is above the legal limit for driving for people 21 years of age or older.

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<sup>16</sup> While participants were asked this question in the questionnaire (closed-ended), the open-ended question in the interview allowed participants to elaborate on their beliefs about drug acceptability. For example, all participants were 18 years of age or older, so they often pointed out that tobacco was acceptable because they were legally able to purchase tobacco. In this case I asked them if age alone was the only reason they believed it was acceptable.

*Alcohol, marijuana, and tobacco abuse and dependence* were assessed using the criteria prescribed by the American Psychiatric Association in the *Diagnosis and Statistical Manual Fourth Edition, Text Revision (DSM-IV-TR)*<sup>17</sup> for Substance Abuse and Dependence. I asked participants questions about their experiences with alcohol, marijuana, and tobacco in regard to the specific behaviors outlined in the DSM-IV-TR criteria. Participants had to meet at least one of the four criteria for substance abuse, and at least three out of the seven criteria for substance dependence. Higher quantities of criteria met for abuse and dependence indicated greater risks associated with the use of alcohol, marijuana, and tobacco.

## Results

All 10 participants were Latino males between the ages of 18 and 24 (mean age of 20.4 years). All ten of the participants were Mexican Americans, and all of them were born in the United States. Five of them (50%) received a high school diploma, four of them dropped out of high school, and one was a senior in high school during the time of the study. The majority of participants (70%) were employed; four of them worked part-time, and three worked full-time. All of the participants had a prior encounter with the criminal justice system at some point in their lives. Most of the participants (70%) had been arrested within 12 months prior to being surveyed; four of them were under county probation and one was on parole at the time of the study. The majority (70%) of participants were raised in households headed by their mothers only (the biological father had either passed away or left the

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<sup>17</sup> I used the DSM IV-TR since it was the latest version available during the time when the interviews were conducted. The main difference between the DSM IV-TR and DSM V is that the latter combines “substance abuse” and “substance dependence” into one category: “substance use disorder.” Although the DSM V uses the same criteria outlined in the previous version, it categorizes the “disorder” along a continuum (mild, moderate, or severe). Also, the DSM V omits one criterion (legal problems) and adds one criterion (craving).

family); six out of the seven young men in this household living arrangement had been arrested within the year prior to the survey.

Most of the participants began using alcohol, marijuana, and tobacco early in their teenage years, with the average initiation age (in years) being 13.45 for alcohol, 11.65 for marijuana, and 12.60 for tobacco. All of the participants had used alcohol and marijuana in the past month at least once. Only alcohol and marijuana were used frequently, with 50% of them using alcohol and 90% using marijuana at least 10 times in the month prior to the survey. Although 60% had used tobacco at least once in the month prior to the survey, only one participant reported smoking tobacco regularly.<sup>18</sup>

### ***Parental Support and Parental Control***

As far as parental and peer attachment, participants were generally more attached to their mothers and close friends than to their fathers. The overall level of attachment to mothers was 95.1 out of 125 possible points, which was only slightly higher than for close friends (94.6), but significantly higher than attachment to fathers (72.1). One of the participants did not complete the questions regarding paternal attachment because his father had passed away during his early childhood. Overall, scores for “communication” were lower than scores for either “trust” or “alienation” among mothers, fathers, and close friends. This suggests that there is a discrepancy between the level of attachment (in terms of trust and intimacy) participants feel towards their parents and close friends and the level of communication with them.

All of the participants said they liked to spend time with their family, and 90% believed that their family was both “close” and “supportive.” However, only 20% talked to their parents about things that were on their mind and asked them for advice at least “often.” In terms of parental communication about drug use, none

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<sup>18</sup> Participants were considered “regular” drug users if they used the substance at least three times per week.

of the participants' parents talked to them frequently about marijuana or tobacco, and only 20% of their parents talked to them about alcohol "often." Accordingly, most of the participants (80%) were considered as having low parental support; this comprised all five of the participants that used alcohol frequently and seven out of the nine that used marijuana frequently.

However, the relationship between the young men and their parents was complex, and lack of parental communication did not translate into lack of caring. In fact, according to these young men, most parents showed they cared about their child's drug use, and some even tried to talk them out of using drugs. Parents that did talk to the participants about drugs usually focused on alcohol rather than marijuana or tobacco. As one participant recalls, "[my parents tell me], 'you shouldn't drink as much.' They see it a lot worse than it is." For some participants, their parents only talked to them about their drug use when it became a problem: "they want me to stop [drinking], kick back a little bit, you know, but before I used to be crazier so they don't even trip on me now." This participant was referring to the time when he and his friends would ditch school and drink 40 oz. bottles of malt liquor while his parents were off at work. Some parents even tried to utilize programs and services in the community to try to help their child stop using drugs: "[my mom] is always telling me, 'just stop, don't do it. I'll put you in [rehab].'" Parents, especially mothers, were sometimes able to successfully convince their child not to drink. As one participant explains, "[my] dad drinks, or he used to drink a lot, so my mom would be like, 'look at your dad, he drinks a lot.' Of course I listen to my mom. I never drink, or I'm not going to be like that... so ever since then I don't want to be like my dad and be all faded every day."

The young men generally reported that their parents exhibited low levels of parental control. While 70% of the participants' parents usually asked them where they were going before leaving the house, 40% said their parents "never" knew where they really were. All of the participants (including three that

were on probation, one that was on parole, and one that was on Electronic Monitoring) were allowed to go out whenever they wanted “often” or “very often.” In addition, 40% of the participants’ parents let them drink alcohol “often” or “very often” (all four of them were old enough to legally drink), but 70% of the participants were not allowed to smoke marijuana. Even though all of the participants could legally use tobacco, 90% said their parents disapproved of smoking tobacco. Correspondingly, 60% of the participants were considered as having low parental control. This included four out of the five participants that used alcohol frequently, and six out of the nine that used marijuana frequently. The one participant that used tobacco regularly reported that his mother often knew of his whereabouts but she permitted him to drink and smoke.

Moreover, parents who exhibited low levels of parental control did so in various ways. For some of the participants, their parents initially rejected their drug use, but eventually they learned to tolerate it, and in some cases even accept it. As one participant says, “They didn’t care about weed... I wouldn’t act stupid [like] when I was drunk... They accept it.” For another participant, his mother would disapprove of his alcohol use when he was a minor, but after he turned 18 she stopped telling him not to drink. One participant, who was still younger than the legal drinking age at the time of the interview, even drank with his father occasionally.

### ***Friends, Family, and Social Factors***

As far as parental and peer attachment, participants were generally more attached to their mothers and close friends than to their fathers. The overall level of attachment to mothers was 95.1 out of 125 possible points, which was only slightly higher than for close friends (94.6), but significantly higher than attachment to fathers (72.1). One of the participants did not complete the questions regarding paternal attachment because his father had passed away during his early childhood. Overall, scores for “communication” were lower than scores for either “trust” or “alienation” among mothers, fathers, and close friends. This

suggests that there is a discrepancy between the level of attachment participants feel towards their parents and close friends (in terms of trust and intimacy) and the level of communication with them.

The belief that “everyone smokes” or “everyone drinks” for social or recreational purposes was very common. Generally, participants were more likely to believe that their friends were regular drug users compared to their relatives. The biggest contrast was with marijuana, with all of the participants believing that at least half of their friends used marijuana regularly compared to only 10% of their relatives. Also, 80% of the participants believed at least half of their friends were regular tobacco users, compared to only 30% of their relatives. The rates for peer and family alcohol use were similar, with 60% believing at least half of their relatives were regular alcohol users compared to 70% of their friends. One respondent who reported that many of his friends and relatives were regular drinkers shared his view on the prevalence of alcohol in his household: “Everyone around here drinks, everybody. My uncles, my sister’s boyfriend, my mom’s boyfriend... everyone.” Interestingly, this participant claimed that everyone in his home drank alcohol though he only mentioned the males in the family. This suggests that these young men often look at male friends and family members as role models through which they develop a sense of manhood.

For many of these young men, using alcohol and marijuana seemed to be a ubiquitous activity. With few exceptions, all of the participants tried alcohol, marijuana, and tobacco for the first time with older siblings and/or close friends. Many of them were exposed to these drugs on the “streets,” and were socialized in a way that made drugs attractive. For example, one participant recalled how when he was 10 years old, he caught his older brother getting high and later told him, “you better get me high.” The use of alcohol and other drugs was so rampant in the neighborhood that drugs were easily obtainable. When asked how easily he can get alcohol, an 18-year-old participant responded, “Anybody could get it, like any day you just have to find the right person. I could

just walk up the street and... [find] someone old enough, you don't even have to know them.” In fact, drugs were so prevalent that their use extended beyond the boundaries of the community. One of the participants pointed out that even people locked up in jail get high and drunk; it is just harder to get and more expensive.

### *Perceptions about Substance Use*

Generally, participants held more positive views towards tobacco and marijuana than alcohol. When asked how acceptable the use of drugs was for someone their age, 40% of the participants believed that using alcohol was either “usually” or “always acceptable” for someone their age, even though only two of them were old enough to legally drink. Forty percent believed marijuana was “always acceptable” for someone their age, compared to 60% who thought tobacco was “always acceptable.” One participant believed marijuana should be acceptable because it has therapeutic uses. He argued: “[Marijuana] helps me... it’s my medication. I wouldn’t stop my mom from taking her meds.”

Marijuana was seen as the least harmful, followed by alcohol, and then tobacco. Seventy percent of the participants considered marijuana to be less than “moderately harmful” for someone their age. On the other hand, most of the participants (90%) believed tobacco was at least “moderately harmful,” and 50% that believed alcohol was at least “moderately harmful.” Some of the participants who had experienced negative consequences as a result of using drugs learned how to modify their behavior to minimize those consequences. As one participant put it, “just because it’s bad for my health doesn’t mean I’m going to stop. I think it’s just more moderation.” By this he meant that over time he learned to use alcohol in a way that reduced the negative effects. However, considering alcohol harmful did not necessarily lead the participants to abstain from drinking. For example, two of the participants reported throwing up blood after consuming excessive amounts of alcohol over a long period of time, yet they continued to drink frequently.

In terms of perceived level of drug risk, two variables were measured: perceived risk of getting in trouble and perceived risks of driving impairment. Drinking alcohol was seen as the most problematic in terms of legal consequences. All of the participants believed alcohol increased their chances of getting into trouble, while none of the participants believed the use of tobacco would do so. Those that believed alcohol was a high-risk substance were more likely to have experienced personal consequences as a result of their alcohol use compared to their counterparts. Understanding that drugs, particularly alcohol, increased the risk of getting into trouble produced a positive effect among some of the participants. One participant recalled that when he was under 21, he would often run into police while he was drunk in public, which would result in arrests for charges varying from Minor in Possession to Disorderly Conduct. He added, “[I would] get taken back to juvenile hall... that was one thing that made me wanna cut down [my alcohol use].” On the other hand, only 20% of them believed marijuana would get them into trouble. In fact, 30% said marijuana would actually decrease their chances of getting into trouble, mainly because they were more likely to think about the consequences and less likely to engage in behavior that might get them into legal problems. As one participant said, “I think your conscience talks to you more [while high]. Everybody just wants to sit on the couch and not do anything.”

In addition, participants believed that using alcohol would eventually impair their driving ability, but they were less likely to think smoking marijuana and tobacco would do so. Half of them said it would take six or more alcohol drinks to impair their ability to drive a vehicle, even though it takes the average male about five alcoholic drinks to get his blood alcohol content (BAC) to 0.08, which is the legal blood alcohol limit for those that are 21 or older. Half of them (50%) said marijuana does not impair their driving at all, and 20% said it would take more than 1/8 of an ounce to inhibit them from wanting to drive, although that amount would not necessarily impair their driving ability. As one participant says, “I

can smoke as much as I want and still [be able to] drive.” On the other hand, 90% said tobacco would not impair their driving at all.

There was a lot of variation in motives for using alcohol, marijuana, and tobacco. Forty percent of respondents drank alcohol for “enhancement” reasons, 40% used alcohol for “social” motives, and 20% used alcohol to cope with negative emotions at least “about half of the time.” Only one participant reported using alcohol as a result of peer pressure “sometimes.” As one respondent said, “I like to drink. Same thing with my generation, you know, drinking is like the thing to do to have a good time.” For marijuana, 80% smoked marijuana for “enhancement,” 50% for “coping,” and only one used marijuana for ‘social’ motives at least “about half of the time.” Using marijuana to increase one’s positive feelings is evident in one participant’s response: “that’s why I smoke weed, to be in a state of mind...with a good high... not to be fucking all stupid.”

Motives for using tobacco were more ambiguous since it was not a commonly used substance. Formal and informal conversations with the young men suggested that many of them only used tobacco while under the influence of alcohol. Being drunk seemed to decrease inhibitions against tobacco use while also making cigarettes seem more appealing because, as many of them claimed, it gave them a better “high.” Also, there is some evidence that tobacco was used for social reasons. According to one participant: “I smoke tobacco with whoever is drunk with me, with whoever gets the cigarettes... It’s like having coffee with someone.”

### ***Substance Use Behaviors***

Many of the participants had engaged in high-risk behaviors within the past year. Eighty percent had driven under the influence of alcohol or had been passengers in a car while the driver was under the influence of alcohol. Most of the participants (70%) were considered binge drinkers, meaning that on average they drank five or more drinks per sitting at least a couple of times a week. Substance abuse and dependence were also relatively high

with 80% abusing alcohol and 40% being dependent on it. For marijuana, 50% were abusing, and 60% were dependent. One participant who was found to be dependent on marijuana exposed one barrier that made it hard for him to stop smoking weed: “I’m thinking about stopping, but it’s just too hard... it’s always in my face. Everywhere I go it’s there.” While this participant did not feel direct peer pressure to use marijuana, according to his answers on the Motives Questionnaire, this statement suggests that his peer group did provide some indirect influence on his marijuana use by making it widely available.

## **Discussion**

My first hypothesis was that participants who reported low parental support and low parental control would begin using alcohol, marijuana, and tobacco at a younger age than participants whose parents provided more support and control. There was not enough evidence to support this claim because most of the participants began using these drugs early in their teenage years, regardless of parental support and parental control. This suggests that among this sample of young Latino men there may be other factors that have a greater influence on early drug onset than parental support and parental control. Peer groups and family members in particular may have played a key role in exposing the young men to alcohol, marijuana, and tobacco since many of the participants reported first using these drugs with their friends, older siblings, or cousins. I also predicted that low parental support and low parental control would be associated with frequent substance use. Preliminary results support this claim because most of the participants that used alcohol and marijuana frequently had low levels of parental support and low levels of parental control.

Next, I expected participants who had high levels of perceived peer and family drug use to be more likely than their counterparts to have positive beliefs about alcohol, marijuana, and tobacco. The majority of participants associated with friends that used alcohol, marijuana, and tobacco, but only alcohol and

marijuana use was prevalent among the participants. One difference between alcohol and the other two substances is that the majority of participants reported that over half of their relatives (60%) and friends (70%) used alcohol regularly, which may have a significant influence on their use of alcohol. For marijuana, all of the participants reported that at least half of their friends used marijuana regularly, but only 10% said at least half of their relatives did. Still, participants reported using marijuana more often than alcohol. This may be because for many of the participants alcohol increased their likelihood of getting into trouble with the law, but that was apparently not the case for marijuana.

My third hypothesis was that participants who had positive beliefs about alcohol, marijuana, and tobacco would be more likely to engage in high-risk substance use behaviors than those with negative beliefs about these drugs. Although participants generally held more positive views toward tobacco—with the exception of perceived harm to one's health—most of them misused alcohol and marijuana, not tobacco. There appeared to be a negative relationship between perceptions about alcohol and high-risk alcohol use behavior since alcohol was seen as the most problematic of the three substances, yet it was also frequently used by half of the participants. Moreover, alcohol abuse, binge drinking, driving under the influence of alcohol, and other alcohol-related problems (ranging from citations for urinating in public to arrests for disturbing the peace) were common among the participants. For marijuana the association seemed to be positive since it was viewed as the least harmful substance, yet most of the participants were found to be abusing and/or dependent on marijuana.

In terms of substance abuse and dependence, 70% were abusing alcohol, 40% were dependent on alcohol, 50% were abusing marijuana, and 60% were dependent on marijuana. One important finding is that most of the participants did not talk frequently to their parents about the use of alcohol, marijuana, or tobacco. For example, only two participants talked to their parents

about alcohol “often” and only one talked to their parents about marijuana “very often.” As other studies have suggested, young men may feel it is acceptable to smoke marijuana unless their parents explicitly tell them otherwise. For example, a study by Lac and colleagues (2011) showed that adolescent boys were less likely to use marijuana when parent-child communication was high.

Finally, I predicted that “enhancement” and “social” motives for using alcohol and marijuana would be the most common reasons participants used these substances. Although this was true, my other hypothesis that participants who used alcohol, marijuana, and tobacco to cope with negative emotions would be more likely to experience problems caused or worsened by using these substances was not supported. For example, marijuana was used for “coping” more often than alcohol or tobacco, yet using alcohol seemed to be more problematic than using marijuana or tobacco. Although marijuana abuse and dependence rates were high, the majority of participants believed that using marijuana had little long-term consequences compared to alcohol and tobacco. Thus, there was not enough evidence to support the claim that using drugs to cope with negative emotions would be associated with substance-related problems.

## **Conclusion and Future Research**

There are many family and peer factors that help shape the way young Latino men perceive the use of alcohol, marijuana, and tobacco. This study contributes to the literature on young Latino men in several ways. First, it shows that this particular group of Latino young adults has elevated rates of substance misuse, including binge drinking, alcohol abuse, and marijuana dependence. Additionally, the Inventory of Parent and Peer Attachment questionnaires suggests that these young men have close relationships with their mothers. Specifically, participants trust and communicate with their mothers significantly more than with their fathers. This may be due to the fact that 70% of the participants lived with their mothers only, and only three

participants lived with both parents. Research on Latino parent-child relationships shows that maternal communication has a positive influence on their daughters' academic performance (Mireles-Rios and Romo 2010); thus, it may be beneficial to assess the ways mothers can play a role in mediating factors associated with substance misuse among Latino men.

Given the preliminary nature of this study, its main limitation is the small sample size. I have only gathered data from 10 participants, so I have not been able to test the hypotheses widely. Also, since all the young men were participants at a community-based program, many of them were close friends with each other. This paper looks at substance use perceptions and behavior among a group of young men that is already predisposed to higher rates of delinquency, thus the data is not representative of all young Latinos in their community. However, I have been able to conduct ethnographic work by "shadowing" some of the young men around their neighborhoods and observing their daily interactions. One important observation based on my informal conversations with some of the participants is that many of them feel marijuana is not harmful to their health and will have little or no consequences on their future. Moreover, many of the participants began using these substances during their early teenage years. Therefore, studies evaluating strategies that are effective in preventing substance use among young Latinos should focus on younger adolescents. Also, it seems that there may be other factors besides family environment that contribute to early exposure to these substances, thus future studies should consider the neighborhood context in which these young men are raised and socialized.

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# The effect of UV radiation on microbial decomposition of plant litter in a California grassland

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## Abstract

*Studies indicate that ultraviolet (UV) radiation increases decomposition rates of litter in arid environments (King et al. 2012), a process known as photodegradation. As pollution depletes the ozone layer, resulting in increases of UV radiation at Earth's surface, it is essential to study the effects of UV radiation on decomposition processes and the overall carbon cycle. Recent work is unclear on whether photodegradation inhibits or enhances subsequent biodegradation. This study investigates the effect of photodegradation on successive microbial decomposition of Bromus diandrus plant litter. We exposed B. diandrus to UV block or pass treatments in the University of California's Sedgwick Reserve near Santa Barbara, CA, for 2.5, 4, 6, or 12 months and incubated the litter in the laboratory to analyze the microbial decomposition rate. The results indicate that UV radiation impedes subsequent microbial decomposition in the short exposure periods, while longer exposure periods showed no response to UV radiation. Overall, the results imply that UV radiation can influence microbial decomposition rates differently depending on the impacts of UV exposure length on the plant litter substrate.*

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## Literature Review

Decomposition, the process by which dead organic matter breaks down into simpler forms of matter such as carbon dioxide and nutrients, is essential to carbon and nutrient cycling. The factors that typically determine decomposition rates are the physical environment (temperature, wind, climate, and moisture), soil properties, and biological activity (Chapin and Mooney 2002). Indeed, decomposition models such as the actual evapotranspiration (AET) linear model incorporate these factors in predictions of decomposition rates (Meentemeyer 1978). However, Whitford et al. (1981) suggests that these factors alone do not accurately model decomposition rates in arid environments.

Whitford et al. (1981) investigated whether the AET linear model of decomposition of surface litter applies to arid environments. The researchers observed that in deserts physical factors like wind bury litter and displace it to a new environment that does not reflect surface litter anymore. They discovered that rainfall and soil temperature accounted for less than 50% of the variation in mass loss of the buried plant litter as compared to the surface litter, while precipitation and air temperature explained 90% of the variation (not taking into account soil fauna). The AET model predicts that desert environments exhibit slower decomposition rates than forests due to low moisture and high temperatures, yet Whitford et al. (1981) observed that litter in arid environments decomposed at equal or greater rates than predicted by the model.

Researchers seek to build a decomposition model representative of arid environments by incorporating photodegradation as a possible mechanism for organic mass loss. Photodegradation is the breakdown of organic matter by solar radiation, especially in the UV wavelength range. As the ozone

layer thins, more UV radiation enters the atmosphere and influences decomposition rates. Researchers have conducted many studies to determine photodegradation's effect on decomposition processes in arid ecosystems.

In order to assess photodegradation's influence on subsequent microbial decomposition, Foereid et al. (2010) conducted experiments exposing *Miscanthus x giganteus* to ultraviolet and visible light for different exposure durations (the longest exposed and shortest exposed were 289 days and 43 days, respectively) and measured the mass loss. They found that all of the litterbags lost 1-4% of the original mass, but there was no correlation between mass loss and exposure time. The researchers then incubated the litter with soil, analyzed the soil for production of CO<sub>2</sub> and N<sub>2</sub>O by microbial organisms, and used the results as an indicator of litter decomposition rates. They observed that the longest exposed litter degraded the fastest, and the shortest exposed litter degraded at about the same rate as the unexposed litter. In this study, photodegradation increased the degradability of the longest exposed plant litter.

Newsham et al. (1999) also reported a positive relationship between UV radiation and microbial decomposition. To assess the effect of UV-B exposure on growing plants, samples were exposed to 30% above the ambient level of UV-A and UV-B, solely UV-A, or un-energized lamps. The authors found that UV-B radiation increased the decomposition rate of the *Q. robur* litter in soil. The UV-B treated litter showed 8% and 6% more weight loss than the UV-A control and the ambient radiation, respectively. UV-B radiation is responsible for increases in mass loss, which correlate with enhanced colonization by fungi and increased microbial decomposition. Both Newsham et al. (1999) and Foereid et al.

(2010) suggest that photodegradation increases the degradability of plant litter for microbial and fungal communities.

Gehrke et al. (1995) investigated changes in litter chemistry as a response to elevated UV radiation and concluded that the rate of microbial decomposition decreased in litter from plants grown in high UV radiation conditions. The authors claim that decomposition rates decreased due to chemical changes in abscised leaves. As stated above, Newsham et al. (1999) reported increased microbial decomposition rates from litter that was exposed to elevated UV radiation levels and no significant changes in litter chemistry. These contrasting studies suggest that different plant species have differing responses to UV radiation.

In addition to the influence of photodegradation on microbial decomposition, many researchers seek the mechanism by which photodegradation occurs. Brandt et al. (2009) observed photochemical mineralization of organic matter to CO<sub>2</sub> and determined this process to be the major mechanism for decomposition of plant litter in arid environments. The researchers noted that the CO<sub>2</sub> production rates were 10 times higher in the UV pass treatment than the UV block. Carbon leaching loss was not dependent on UV exposure, and there were no increases in carbon loss via microbial decomposition of pre-exposed litter. Therefore, between leaching, enhancement of microbial decomposition, and photochemical mineralization, the only mechanism of photodegradation that was observed in this study was photochemical mineralization to CO<sub>2</sub>.

Researchers have attempted to use changes in litter chemistry to discover which compounds are affected by UV radiation. Some photodegradation studies identify lignin as the plant synthesized compound broken down by UV radiation. Lignin is a recalcitrant compound in biotic degradation; it blocks labile

carbon from further microbial enzyme biodegradation. Lignin is also a light-absorbing compound (Moorhead and Callaghan 1994). Because of these characteristics, Austin and Ballaré (2010) hypothesized that photochemical degradation of lignin causes mass loss. They conducted an experiment by subjecting filter paper, as a representation of plant litter, to specific wavelengths of solar radiation, enriching the litter with lignin and cellulose, and measuring changes in concentration of lignin and cellulose. In summary, as lignin concentration increased in the samples, light absorbance increased— indicating that lignin is a light-absorbing compound. Moreover, there was a positive relationship between lignin concentration and mass loss in samples exposed to solar radiation. On the other hand, there was a negative relationship between lignin concentration and biotic mass loss in samples shielded from solar radiation. Additionally, biotic degradation resulted in increases in lignin concentration, while photodegradation resulted in decreases in lignin concentration. The findings suggest that lignin is the principal light-absorbing compound that is preferentially decomposed to labile products during photochemical degradation.

Some biological studies on the effect of UV radiation on microbial communities indicate that UV radiation can have negative effects on these communities depending on their location in the soil and ability to adapt to elevated UV levels. Belnap et al. (2008) examined the sensitivity of biological soil crusts (BSCs) (cyanobacteria, algae, lichens, and mosses) under field conditions by studying them under near-ambient UV and altering precipitation and temperature for two years. During the last 11 months of the study period—when average temperatures were higher than temperatures in the initial months—researchers observed decreased photosynthesis in the BSCs. These reductions are reflective of

decreased BSC activity as a response to increased UV radiation and high temperatures. Belnap et al. (2008) attribute this response to a lack of the necessary metabolic activity in drier soils to repair UV damaged apparatus. The results from this study would predict that photodegradation has a negative relationship with microbial decomposition; however, via a meta-analysis of current and past literature, Johnson (2003) suggests that the effect of UV radiation on microorganisms depends on several factors such as the organism's species, pigmentation, location in the soil profile, and ability to adapt.

In Newsham et al. (1997), the species negatively affected by increased levels of UV radiation were the lighter pigmented organisms; pigmentation of surface microorganisms may play a role in microorganism's structural response to elevated UV radiation. Additionally, Gunasekera et al. (1997) demonstrated that yeast cultured from plants in high altitudes was less sensitive to UV than yeast cultured from plants in low altitudes. These studies both emphasize the ability of surface microorganisms to structurally adapt to high UV levels.

Soil microbial communities are likely to be more indirectly affected by UV radiation than surface microorganisms. Because soil microbes are not directly exposed to light, it is likely that they are affected by changes in litter chemistry, biomass, and plant species composition. Gunasekera et al. (1997) demonstrate that UV radiation can alter the composition of soil bacterial and fungal communities shown by shifts in carbon utilization.

Mycorrhizal fungi are of particular importance in grassland environments. Staij et al. (1999) observed reductions in arbuscular fungal communities during a 5-year exposure to elevated UV radiation. The potential decline of this community is

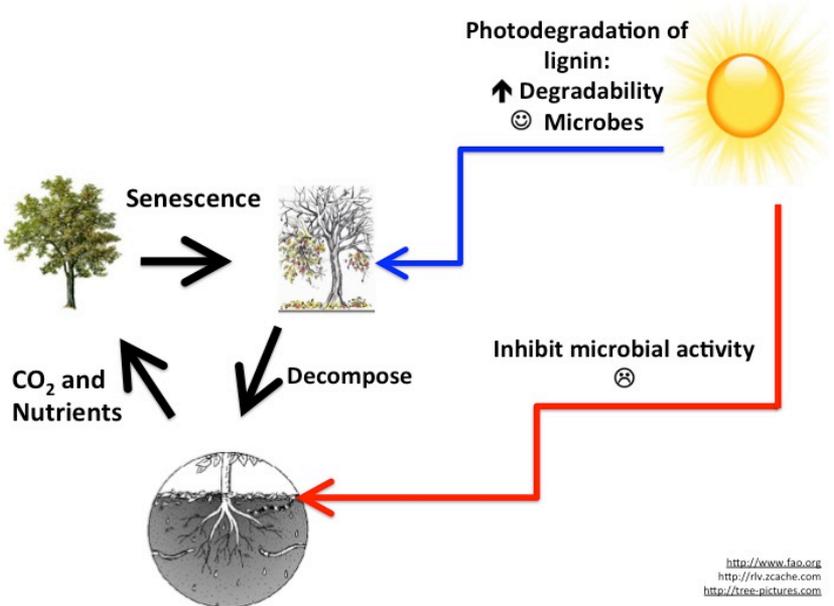
crucial because as plant symbionts, they are important sites for carbon and nutrient exchanges between plants and their environment. The effects of UV radiation on microbial and fungal communities widely vary just as the influence and mechanism of photodegradation are widely debated.

Experimental methodology could play a large role in explaining the contrasting findings on the mechanism and effect of photodegradation. Pancotto et al. (2005) discovered that decomposition rates from UV treatments would differ based on treatments during growth or decomposition. Litter samples *grown* under ambient UV radiation decomposed slower in ambient UV than in reduced exposure treatments; litter samples *decomposed* under ambient UV exposure had higher decomposition rates than reduced exposure treatments. Likewise, Feng et al. (2011) demonstrated that the effect of photodegradation on subsequent microbial decomposition depends on the plant litter type. They observed that pine litter exhibited increases in water-extractable organic carbon from photodegradation, while maize litter did not. As previously stated, UV radiation could have different effects on different plant species.

Researchers have observed various conflicting mechanisms specifying how photodegradation works in the decomposition process. Photodegradation can enhance decomposition through abiotic photochemical mineralization, facilitate microbial decomposition through the photodegradation of lignin, inhibit microbial decomposition through other changes in litter chemistry, or alter microbial and fungal abilities. With the many contrasting studies on the mechanism of photodegradation on plant litter in arid environments, it is difficult to incorporate photodegradation into decomposition models. As increasing amounts of UV

radiation enter the atmosphere and reach Earth’s surface, it becomes important to know the effect of UV radiation on the carbon cycle.

It is critical that researchers continue to advance knowledge on photodegradation so that the decomposition of plant litter can be better understood. In this study, we examined the proposed mechanism of UV radiation exposure leading to microbial decomposition. We hypothesized that UV radiation would increase subsequent microbial decomposition, as suggested in past literature (Figure 1).



**Figure 1. Mechanisms of effects of photodegradation on microbial decomposition from past literature**

**Methods**

The study site that the experiment was conducted on was the University of California Sedgwick Reserve in Santa Ynez, California (43°42’N, 120°2’W), encompassing about 24 square

kilometers on the southern slopes of the San Rafael Mountains. The Reserve experiences a Mediterranean climate with average temperatures at 16.8°C, average annual precipitation at 380 mm, and about 320 MJ m<sup>-2</sup> of UV radiation during the one year experiment. *Bromus diandrus* is one of the dominant plants in the grassland and is the plant species used for this experiment.

The experimental design consisted of manipulating the amount of UV radiation received by each litter layer using UV-transparent acrylic (UV pass; transmits 90% UV-A and UV-B radiation) and UV-absorbing polycarbonate (blocks 90% UV-A and UV-B radiation). Both materials pass 85% photosynthetically active radiation (PAR).

The first litter treatment type was exposed for 2.5 months, between mid August and late October 2011. At the end of the exposure, litter from the upper layer was oven-dried, ground, and stored in a dark place before the incubation. The second litter treatment type was exposed from June 2012 to October 2012 (4-month exposure time). The third litter treatment spanned from August 2011 to March 2012 (6-month exposure time). The fourth litter treatment was exposed from August 2012 to September 2012 (12-month exposure time). In each experiment there were 10 replicates for each UV block/pass treatment, and four replicates from each were used in the incubation study.

The litterbags used were 20 cm by 20 cm and contained *B. diandrus* litter. The samples were placed under a UV screen (block or pass) and were supported by steel mesh (which allows >70% solar radiation). To ensure that the UV screens functioned properly, we checked the radiation monthly using a radiometer. Temperature was also tracked using sealed temperature sensors. After collection, litter was oven-dried, sealed, and stored in a dark

area. For more details, see the experimental design in Lin and King et al. (2013).

In order to prepare microbial inoculum for the incubation study, 100 grams of soil and 350 mL of DI water were combined in an empty jar. The jar was mixed well and placed on a shaker for an hour and a half. The jar sat overnight, uncovered. The next day, soil was filtered out of the soil and water mixture using a Buchner funnel vacuum system to create a soil inoculum. Each experimental microcosm included between 0.24-0.26 g of litter, 2 mL water, and 250  $\mu$ L inoculum. The materials were placed in a small beaker within a large 432 mL jar. Each jar was sealed with a lid and fitted with a blue butyl rubber stopper for headspace sampling.

There were a total of 42 jars. Four jars were control jars containing only inoculum, and water. Four more jars were left empty and served as blank controls. The samples were analyzed for CO<sub>2</sub> production every 24-48 hours using an IRGA (Infrared Gas Analyzer). The jars were incubated in the dark at room temperature. After removing a 1 mL headspace sample from each jar and injecting it into the IRGA for analysis, each jar was opened and allowed to re-equilibrate to ambient CO<sub>2</sub> levels. The timing of sampling and jar closure was recorded to calculate CO<sub>2</sub> accumulation rates. Data was extracted and manipulated using R. The concentration of CO<sub>2</sub> (in ppm) was then converted to CO<sub>2</sub> production rate per hour using the ideal gas law (equation  $PV=nRT$ ).

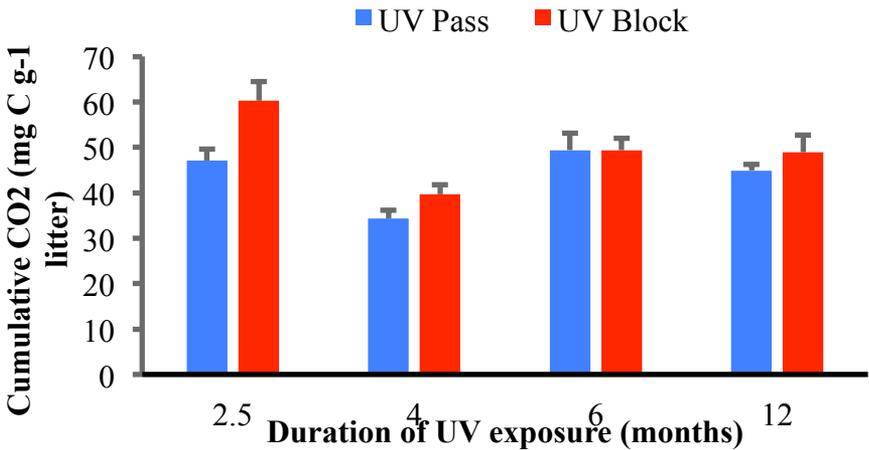
## Results

The UV-unexposed litter treated for 2.5 months produced significantly more CO<sub>2</sub> over a 25-day incubation period than the UV-exposed litter under the same exposure time (**Figure 2**). In

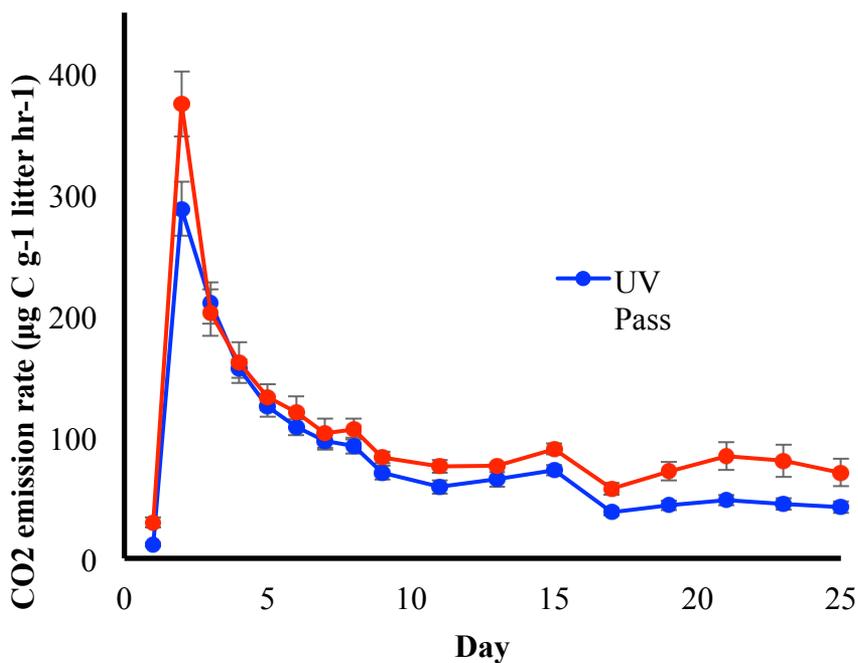
addition to the overall production of more CO<sub>2</sub> in the UV-unexposed than UV-exposed litter, the unexposed litter showed higher rates of CO<sub>2</sub> production per gram of litter per hour than the exposed litter (except for day 3) (**Figure 3**).

The unexposed litter under the 4-month exposure period showed the same pattern as the 2.5-month exposure period. The unexposed litter produced more cumulative CO<sub>2</sub> than the exposed litter (**Figure 2**); and, during the first 13 days of incubation, it exhibited higher rates of CO<sub>2</sub> production per gram of litter per hour than exposed litter (**Figure 4**).

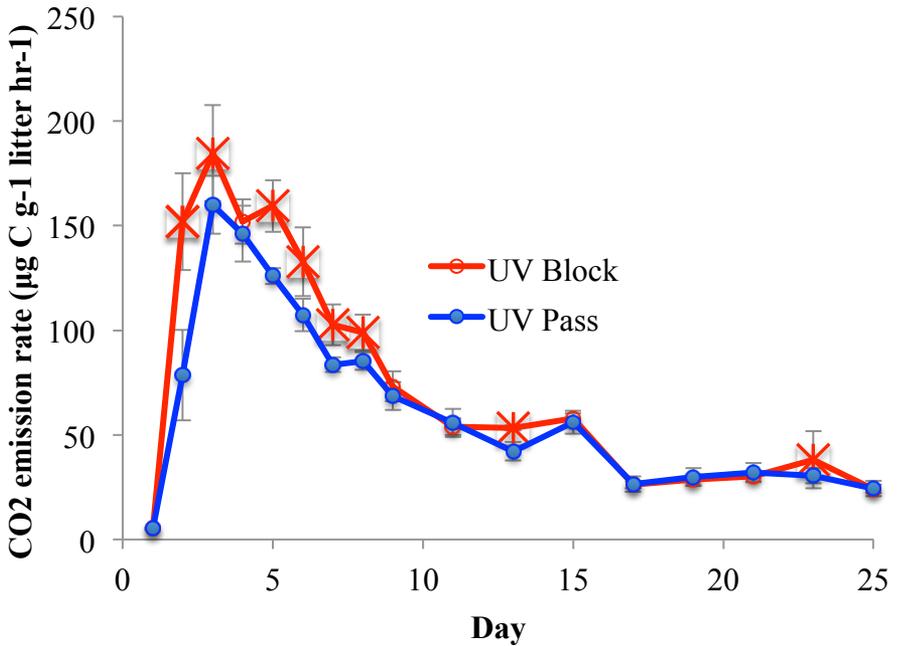
The 6-month UV-treated litter exhibits different patterns than the shorter exposure periods. The litter treated under this exposure period, both UV-exposed and UV-unexposed, produced relatively the same cumulative CO<sub>2</sub> and showed statistically indistinguishable rates of CO<sub>2</sub> production per gram of litter per hour (**Figure 2 and Figure 5**). The litter under 12-month treatment, like the 6-month treatment, showed no statistically significant effect of UV radiation (**Figure 2**).



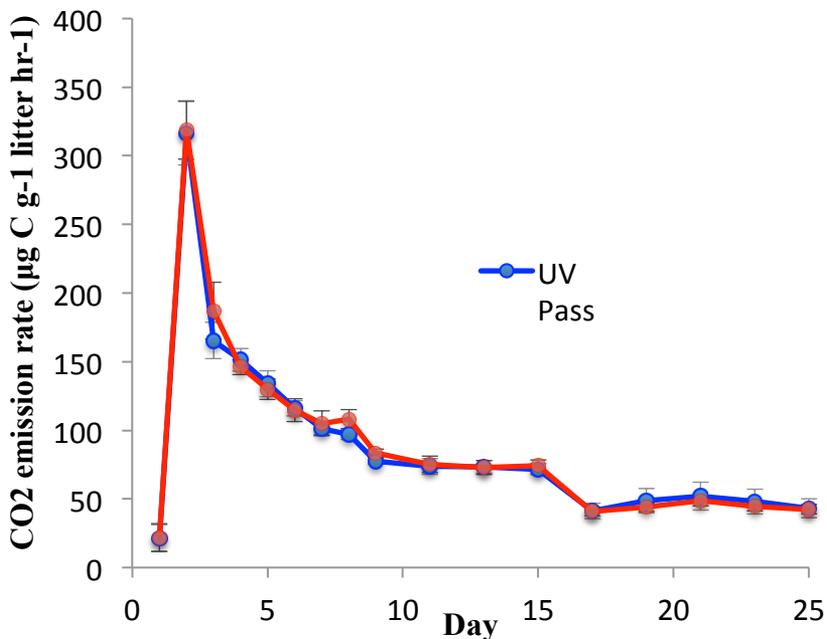
**Figure 2. Cumulative CO<sub>2</sub> production from litter of varying UV exposure times.**



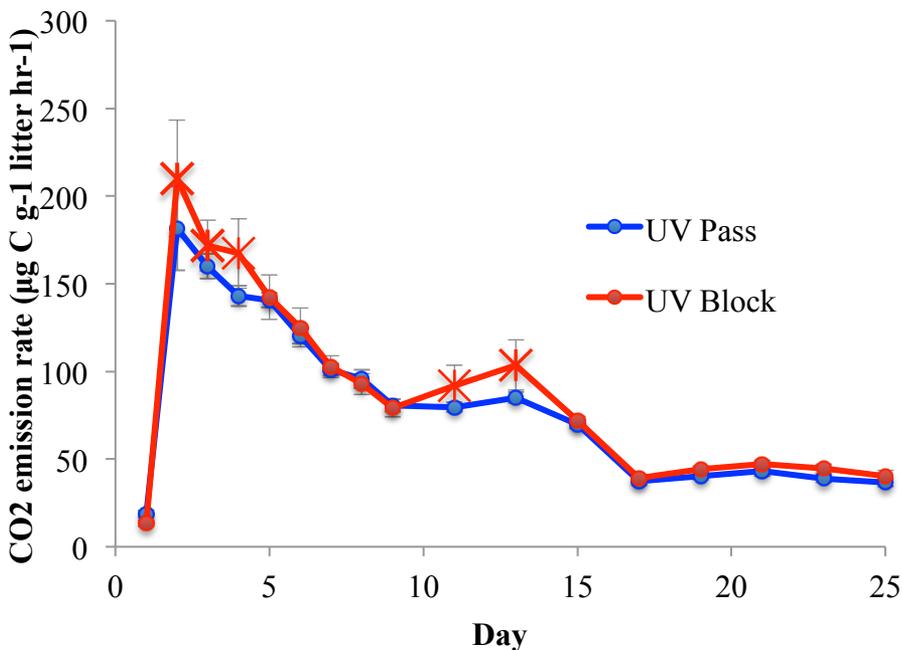
**Figure 3. Average daily CO<sub>2</sub> emission rate (n=4-5) for litter under UV block or pass treatments for 2.5 months. The UV block treatment shows consistently higher emission rates than the UV pass treatment (except for Day 3).**



**Figure 4. Average daily CO<sub>2</sub> emission rate (n=4-5) for litter under UV block or pass treatments for 4 months. The UV block treatment shows higher emission rates than the UV pass treatment on most days.**



**Figure 5. Average daily CO<sub>2</sub> emission rate (n=4-5) for litter under UV block or pass treatments for 6 months. The rates for the two UV treatments are not significantly different from each other.**



**Figure 6. Average daily CO<sub>2</sub> emission rate (n=4-5) for litter under UV block or pass treatments for 12 months.**

## Discussion

Of the four exposure periods, the 2.5-month treatment showed the most significant difference in CO<sub>2</sub> production between UV-exposed and UV-unexposed litter. The lower CO<sub>2</sub> production in litter exposed to UV radiation suggests that UV radiation impedes subsequent microbial decomposition in short exposure periods.

Austin and Ballaré (2010) indicate that lignin—a recalcitrant compound in microbial decomposition—is the principal UV-absorbing compound in plant litter, and it is photodegraded into a more biodegradable compound. Therefore, researchers attribute higher degradability of UV-exposed litter

(Foereid et al. 2010) to the photodegradation of a recalcitrant compound to a biodegradable compound. Because UV-exposed litter exhibited the lowest rates of CO<sub>2</sub> production in this experiment, photodegradation made *B. diandrus* litter less degradable during microbial decomposition. In *B. diandrus*, UV radiation may instead target other UV-absorbing compounds and decompose these compounds into more recalcitrant forms that decrease microbial decomposition rates. Therefore, we propose that the microbial community decomposes the UV-exposed litter slower than the UV-unexposed *B. diandrus* due to an accumulation of recalcitrant compounds in the litter.

The inhibitory effect of UV radiation on microbial decomposition could also occur due to changes in nitrogen content between UV-exposed and UV-unexposed litter. According to Belnap et al. (2008), direct UV radiation can negatively impact the microbial communities' ability to decompose plant litter. Therefore, while the plant litter was decomposing under field conditions, the microbial communities in the UV-exposed litter are physiologically impacted by UV radiation. The damages to the microbial community cause it to fix less nitrogen. On the other hand, the microbial communities in the UV-unexposed plant litter are metabolizing the litter faster and fixing more nitrogen. Laboratory analysis indicates that nitrogen content during exposure was higher in UV-unexposed litter than UV-exposed litter (Lin, Scarlett, and King unpublished data). Because UV-unexposed litter accumulated more nutrients like nitrogen, the microbial communities colonizing the litter during the incubation can use the nitrogen. In comparison to the UV-unexposed litter, the UV-exposed litter contains less nitrogen for the microbes to consume as a nutrient, so the rate of decomposition is slower during incubation.

Evidence of the inhibitory effect of UV-radiation on microbial decomposition only occurs during 2.5 and 4-month exposure periods. This is possibly due to changes in weather conditions between the different treatments. The 2.5-month and 4-month treatments spanned from August 2011 to October 2011 and

June 2012 to October 2012, respectively, and experienced minimal moisture. Those treatments showed higher CO<sub>2</sub> production in unexposed litter than exposed litter (**Figure 2**). The 6-month and 12-month treatment experienced rainfall during exposure from July 2011 to March 2012 and September 2012, respectively, and showed no significant effect of UV radiation. Moisture could have promoted subsequent microbial decomposition by leaching the recalcitrant compounds from the litter (assuming that the molecules are soluble in water). Leaching would effectively counteract the effects of UV-radiation and equalize the rates of decomposition in the exposed and unexposed litter.

## **Conclusion and Future Work**

Overall, the results from this experiment show that with short UV exposure periods, UV radiation impedes subsequent microbial decomposition by making *B. diandrus* less degradable. On one hand, the results suggest that plant litter of differing chemical composition will react with UV radiation differently. On the other hand, UV radiation could have physiologically inhibited microbial activity thus causing them to create a less favorable environment for colonizing communities during the incubation period. The influence of water in this experiment helps to draw a stronger conclusion. In addition to leaching of recalcitrant compounds, water can also mobilize nitrogen. If nitrogen content on both UV-exposed and UV-unexposed litter were mobilized from the surface of the litter during rain (6 and 12-month periods), then both treatments would have a randomized amount of nitrogen. The mobilization of nitrogen could cause UV-exposed and unexposed treatments to have similar nitrogenous environments for colonizing microbes, and therefore similar decomposition rates.

In the future, we will test our hypothesis that UV radiation reacts with different compounds depending on the chemical composition of the litter by compiling these data with litter chemistry analyses to examine which molecule is UV-absorbing in *B. diandrus*.

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# Transnational Generations: Mixtec Migrants in Oxnard, California

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## Abstract

*This project explores the historical patterns of migration to California influenced by the pull factors of agricultural labor and social networks. As first proposed by Carey McWilliams, California's agriculture relies heavily on new vulnerable migrant ethnic groups. There is a constant change of ethnic laborers in the industry as one ethnic group leaves agriculture and some members of the group settle in rural communities, achieve upward mobility, and form transnational links to their community of origin. I argue that Mixtec migrants came to California attracted by industrial agriculture as many ethnic migrant groups have done in the past. Based on my case study of the community of San Francisco Higos from the southern Mixtec region in Oaxaca, Mexico, I claim that as Mixtecs attain legal residency, higher education, and other forms of upward mobility, they settle in rural communities like Oxnard and create transnational networks. I pay attention to the transnational resilience of San Francisco Higos migrants in California as it affects their adaptation experience and community participation. I explore the role of the second generation as these youth organize themselves to maintain and change traditional community civic practices. This generation is changing the context of transnational community participation despite increasing social and economic changes in their lives.*

## Introduction

*On a Sunday, around 6:00 pm, I arrived at the house of a San Francisco Higos family in Oxnard, California. The family lived in the southern part of the city, between Wooley Road and Elm Elementary School. The house was a typical suburban Oxnard house; one floor, probably three or four bedrooms, a spacious and well-maintained front yard with ten-inch plants and many flowers. A group of men, dressed in semi formal attire (dress pants and collared shirts) greeted and guided me to the home's backyard.*

*We sat in front of an altar of the patron Saint of San Francisco de Asis (St. Francis) situated between a corner made by the house's garage and back door. Many flowers pots, candles, and cherry and gold colored ribbons surrounded the altar. Several couples arrived; while the women went to the rear of the backyard where they prepared tamales, the men stayed and talked with each other. After the cocinera (female cook) told one of the men the food was ready, we proceeded to one of the tables the men arranged. I joined with other men and their children who were playing around the house. The men joked about their diet. One of them counted the number of tamales his peer ate. He counted them in three languages: English, Spanish, and Mixteco. These three languages, the well-maintained suburban house, the beautifully arranged Catholic altar, and the traditional food, made this suburban backyard a social and physical space intertwined by languages, cultures, beliefs, genders, generations, and countries.*

This backyard gathering was a *rosario*, a day of prayer in honor of the patron saint of the community. It happened in September 2012. As a tradition, *rosarios* are usually held weeks before the celebration of St. Francis Day. In San Francisco Higos,

a town in the Mixtec region of Oaxaca, Mexico, the celebration takes place on October 4th, but in Oxnard, an agricultural community in Southern California, the migrants hold the celebration on the outskirts of the city on a Saturday. In 2012, the celebration's date was October 6<sup>th</sup>. The men and women I talked to were part of the *Mayordomia*, a traditional group that organizes the important Catholic celebrations for the community of San Francisco Higos. These men and women are members of an extended family that composed the San Francisco Higos *mayordomia* in Oxnard.

Similar to the San Francisco Higos migrant community, other Mixtec communities, for example San Martin Peras and Santiago Asuncion, also celebrate their customs and traditions in Oxnard, California. Mixtecs are an indigenous ethnic group that inhabits the *Mixteca* Region located within the states of Guerrero, Puebla, and Oaxaca. In the past decades, Mixtecs have migrated to California. In this paper, I seek to understand the migration and settlement experience of these Mixtec migrants to Oxnard.

I use the San Francisco Higos as a case study to explore the reasons Mixtec communities came to Oxnard. I examine the economic and social forces that drive Mixtec migration to this city and investigate the forces that affect the process of settlement of Mixtecs. In addition, I ask about the role of transnationalism in the process of migration and settlement. I also examine the role of Mixtec children who grow up in the United States in the transnational community of San Francisco Higos, including focusing on their level of participation in community customs and traditions and how it compares to that of their parents. I ask questions about whether and how the youth reproduce/learn/adopt Mixtec identity; are they interested? Are there changes and new adaptations? I begin to tackle these questions by providing an historical overview of migration to California focusing on Mexican migration and Mixtec migration. Through life histories and genealogical analysis, I then explore the migration, transnational networks, and economic experiences of San Francisco Higos migrants in Oxnard.

As a member of the San Francisco Higos community, my status as an insider ethnographer influenced the frame of reference I use to describe indigenous people. Gaspar Rivera Salgado and Jonathan Fox in the introduction to their anthology *Indigenous Mexican Migrants in the United States* discuss their decision to frame migrants as “social actors” rather than “passive victims” or “faceless flows of amorphous masses” (Salgado and Fox 2004). Indigenous migrants are often either idealized or framed as oppressed souls. As Rivera-Salgado and Fox do, I step away from the stereotype of the “hopeless soul.” Rather, I focus on the efforts of Mixtec migrants to achieve socioeconomic mobility through migration and the effects this process has on migrants’ culture. This work recounts that despite difficulties with gender and ethnic discrimination, immigration laws, and labor exploitation, San Francisco Higos migrants manage to be resilient in the face of the hierarchy of industrial economic systems and build a transnational community.

## **Literature Review**

### ***The History of Mexican Migration and Settlement in California***

The intensification and mechanization of labor created the path for migration in California. The amount of human labor required in California increased as agriculture progressed to corporate ownership in the late nineteenth century (McWilliams 1939). Historically, Chinese, Japanese, Native Americans, Armenians, Filipinos, Mexicans, and American dust bowl migrants served as agricultural workers in California. Each of these migrant groups left agricultural work as they achieved social and economic mobility or sought better work conditions. New migrant groups replaced each group that left the industry. Hiring new migrants was beneficial to agricultural growers that preferred unorganized and exploitable workers.

In the early 1940s, as the United States became engulfed in World War II, agricultural employers insisted that the United States government negotiate a bi-national agreement with the

Mexican government to arrange for the implementation of the Bracero program (1942-1960). This program brought Mexican laborers to agricultural growers in the United States. As participants in a form of “administered migration,” the Braceros were supervised by and dependent on their employers (Galarza 1964). In contrast to the system of replacement of workers presented by McWilliams, administered migration benefitted agricultural growers because it prevented workers from acquiring socioeconomic mobility, organizing, and contesting low wages and harsh working conditions. The Bracero Program, as an experiment in farm labor management, was useful to growers because it provided them with a constant flow of vulnerable “guest workers” while not holding them accountable for or responsible to their employees.

The Bracero Program facilitated a consistent flow of Mexican migration to the United States in subsequent decades. Between 1980 and 1994, agriculture increased in value by 50% as farming production changed to high value specialty crops such as fruits and vegetables (Palerm 1999, 46). Agricultural production became increasingly profitable for growers and created more production value, more jobs and more state income (Palerm 1999, 46). The increase in farming production attracted Mexican migrants that continued migration through social processes - community networks that link sending communities to specific locations in the United States. These networks include family, community, friendships, and organizations (Massey 1987, 139). Migrants rely on networks that know the labor force in receiving communities and therefore expand the influx of migrants to these California rural communities when employment opportunities arise.

The social processes of migration and the implementation of the Immigration Reform and Control Act (IRCA) of 1986 led to the creation of California rural communities heavily populated by Mexicans. Many Mexican migrants have settled near sites of intensive agricultural activity and created transnational communities that are made up of the sending and the receiving

communities, each of which is dependent on the other for social, cultural, and economic development. Juan Vicente Palerm and Jose Ignacio Urquiola, for example, examine the historical ties between the communities of Guadalupe, California and Valle de Santiago in Guanajuato Mexico (Palerm and Urquiola 1993), and address the economic and cultural dependency between a California rural community and a Mexican community, which depended heavily on migrants' economic development.

The migration and settlement of agricultural workers in California has been influenced by the ethnic replacement of workers in the agricultural industry and the social process of migration that link sending communities in Mexico and receiving communities in California. The case of Guadalupe, CA and Valle de Santiago, Mexico exemplifies the settlement patterns of Mexican migrants in California's rural communities and is the basis of my analysis of Mixtec migration to Oxnard, California.

### ***Mixtec Migration and Settlement***

In the 1980s Mixtec laborers were the next ethnic groups to be employed by agricultural growers and thus would be the next ethnic group in California's "ethnic replacement cycle" in the late twentieth century (Kearney 1993, 88). Mixtec migrant laborers have replaced Mexican laborers from the highlands of Mexico (Guanajuato, Michoacán, Jalisco, Zacatecas) in the agricultural labor force. Mixtecs, in contrast to other Mexican workers, are indigenous people with a different language, phenotype, and culture. Mixtecs encounter racism and discrimination from their Mexican *Mestizo* (Indigenous and Spaniard) counterparts. Racial and ethnic difference makes them vulnerable to exploitation and poor treatment by both growers and other Mexican immigrants.

Like the migrants from Valle de Santiago, Mixtecs migrate to California in search of work, and they have settled in rural communities where agriculture continues to intensify. The Mixtec transnational migration began in the 1970s. By 1991, the Mixtec population in California reached 50,000 (Lopez and Runsten 2004,

256). For example, members of Asuncion Naranjos, probably one of the first Mixtec communities in Ventura County, began arriving in Oxnard in 1977 (Lopez and Runsten 2004). Indigenous farm workers have become a crucial component in agriculture, especially in labor-intensive crops such as strawberries, tomatoes, grapes, and citrus (Stephen 2001, 5). Lynn Stephen states that many indigenous workers who came to the United States as undocumented workers during the 1980s were legalized under the 1986 Special Agricultural Worker program (SAW) within the Immigration Reforms and Control Act (IRCA) (Stephen 2001, 7). SAW created the conditions that allowed Mixtec laborers to bring their families and settle in the United States.

IRCA provided the legal route that facilitated the formation of Mixtec transnational communities in California. According to Gaspar Rivera-Salgado and Jonathan Fox (2004), this settlement pattern resulted in community participation in both Mexico and the United States. The authors introduce the concept of “translocal community citizenship” in which Mixtec migrants become active agents in both their community of settlement and community of origin. Stephen further explores the role of transnationalism by analyzing the role of hometown associations, spaces where migrants can reconnect with their language, networks, and political organization (Stephen 2004, 195). Moreover, owning land in their home communities defines community membership and therefore requires political participation of many Mixtecs (Kearney and Besserer 2004). This participation is achieved through *cargos* in which each male member of Mixtec families is accountable for responsibilities in the community, both in the United States and Mexico. Transnationalism in Mixtec communities serves as a social process that expands the settlement of Mixtec migrants in California’s rural communities primarily populated by Mexican workers from the highlands of Mexico.

### ***Mixtec Transnationalism***

Transnationalism is defined as the “process in which immigrants forge and sustain multi-stranded social relations that

link together their societies of origin and settlement” (Basch et. al. 1994, 7). In this paper, I explore the role of transnationalism as a factor in San Francisco Higos migration and settlement in Oxnard, CA and the participation of migrants within community transnationalism.

Indigenous communities like San Francisco Higos differ from other Mexican communities because, as indigenous peoples, they encounter more disadvantages in two nation-states than other migrant groups. Lynn Stephen introduces the concept of *transborder* to describe the lives of indigenous migrants from San Agustin Atenango and Teotitlan de Valle because “they cross ethnic, class, cultural, colonial, and state borders within Mexico as well at the U.S. –Mexico border and in different regions of the United States (Stephen 2007, 6).” Stephen’s study expands the concept of “borders” beyond geo-political borders to include social barriers Mixtecs confront in Mexico and the United States.

### ***California Local Receiving Communities***

Mixtecs arrived in California rural communities that have historically experienced ethnic, racial and class divisions. In *The Mexican Outsiders (1995)*, Martha Menchaca explores the history of Mexicans in Santa Paula, CA. Menchaca describes the historic relationship between two groups, Anglo Americans and Mexican descendants, which have been geographically and socially separated. She examines how the membership of the Santa Paula city council changed from being composed of Anglo American growers who economically dominated Santa Paula to Mexican Americans who have gained political influence in the community. Furthermore, her analysis reveals that conflict exists not only between Anglos and Mexicans but also between older Mexican settlers and newer Mexican migrants. Travis Du Bry (2007) discusses the development of Mecca in the Coachella Valley as Mexican immigrants transform it. Du Bry argues that settlement is influenced by the industrial agricultural changes such as the production of specialty crops (fruits, nuts, and vegetables). He

emphasizes the success of migrant farm workers in the socioeconomic hierarchy and their contribution to Mecca's development. As farm workers obtained better occupations in the labor force, they gained influence in the community, including political influence and positions.

Du Bry (2007) mentions interethnic tensions between the Mexican *mestizos* and indigenous Purepecha migrants. He identifies three cultural identities within the Mecca rural community: "The Mexican *Indigenas* are the most marginalized portion of the populace of Mecca. Most are Purepecha, or Tarascan Indians from the highlands of Michoacan, but there are also Mixes and Mixtecos from Oaxaca as well. Mexican-Americans commonly referred to indigenous migrants using condescending words such as backward, primitive, strange, and dark and diminutives like *Muchachito* or *chaca*. (p. 177) Du Bry's study provides an example of ethnic, class, and racial borders that indigenous migrants encounter in California's rural communities. It is because of these borders that indigenous transnationalism, as a process for social and economic relations, is a space of resilience and resistance to the challenges indigenous people confront in the United States.

Following the tradition of exploring transnational migration and transborder lives, I expand upon previous research through an examination of how migrants from San Francisco Higos participate in their transnational community. The people of San Francisco Higos forge a transnational community that links their community of origin in Oaxaca, Mexico to Oxnard, in central California. I explore the formation of San Francisco Higos transnationalism as it is formed in Oxnard in the midst of the social and economic changes and the challenges its members experience.

## **Methodology**

I use ethnography to analyze the migration and settlement experience of the San Francisco Higos community from Oaxaca, Mexico to Oxnard, California. I examine the connection between the migrant community of San Francisco Higos in Oxnard and the

homeland community back in Oaxaca, Mexico. This connection is analyzed through participant observation of the civic and cultural activities of community members in both San Francisco Higos and Oxnard, including participation in *Fiestas Patronales*, Youth Organizations, and *Comite de Cooperacion*. I recorded my observations through journals, videos, photos, and sound recordings.

I created genealogies, kinship diagrams, where I mapped different family generations of the participants. This included the grandparents, parents, and children. Genealogies, as part of the empirical study, helped me analyze the familial and worker history of migrants. I learned about socioeconomic mobility and political participation of family members. This methodology was crucial to the collection of information about San Francisco Higos' migration, settlement, and identity formation away from Oaxaca. It gives us a clear look at the effects of the economy on the migrant household (Boehm 2012).

I also analyzed secondary data, including reports on population, employment, and civic participation. To understand Mixtec population in Oxnard, I focused on the work of the Mixteco/Indigena Community Organizing Project, a non-profit organization based in Oxnard that works with Mixtec families and youth in Ventura County. I utilized the information presented in the Ventura County Crop Report and the California Farmworker Study to analyze agricultural production and economic stability of agriculture in Oxnard. I analyzed this data to examine the relationships between the agricultural industry and migrant labor and to analyze the current migration growth of Mixtec migrants in the area. The secondary data enabled me to understand the economic development of the Ventura county area as it paints a picture of the economic circumstances into which Mixtec migrants arrived.

In December of 2012, I traveled to Oaxaca, Mexico to investigate the participation of migrants in San Francisco Higos

mayordomias - traditional groups in the community that organize a community celebration. In that particular year, community members did not volunteer to organize the celebrations in San Francisco Higos. I examined the reasons why they did not volunteer. Since migrants in the United States commonly organize community celebrations, I hypothesized that problems within the San Francisco Higos transnational community had led to the decline of mayordomias. To prove my hypothesis, I did participant observation in community meetings and I interviewed active participants in community celebrations.

Much of the data gathered throughout this research is influenced by my position as an insider ethnographer. For example, I had access to community celebrations and meetings. However, I also experienced difficulties. These included the fear that some expressed that I might gossip about things community members of their personal experiences and points of view. In addition, as an insider researcher, I needed to refrain from expressing my own positions on certain political conflicts that occurred in the transnational experience of San Francisco Higos.

## **Data**

### ***Ventura County: Agriculture, Ethnic Replacement, and Mixtecs***

As of 2010, Oxnard's population is 197,899 of which 73.5% is of Hispanic descent (Census Bureau 2010). Since Oxnard is located within the heavily agricultural Ventura County, it is a community in which migrants settle to work as farm laborers. Ventura County produced \$740,039,000 in fruit and nut crops in 2004 and vegetable crops yielded \$354, 514,000 in the same year (Ventura County Farm Bureau). That year, strawberry was the leading commodity producing \$363,646,000. By 2011, the fruit and nut crops were valued at \$1,124,860,000 and vegetable crops reached \$490,233,000. Once again, strawberry was the leading commodity, with a value of \$625,509,000. The comparisons between 2004 and 2011 crop production value demonstrate the continuing importance of agriculture to the county.

Despite acreage loss to urbanization, Ventura County's agricultural industry has demonstrated constant growth and therefore it attracts Mexican migrants that come to work as farm laborers. In Ventura County, strawberry is the major specialty crop, producing more income value for the growers than any other crop. It also requires more expensive production techniques and sophisticated farming.

As Mexican workers from northern Mexico settled and achieved upward mobility in Oxnard, indigenous workers, primarily Mixtec, were located at the lowest rank of the agricultural industry. As McWilliams suggests, the vulnerability of new migrants influences the choice of ethnic work force in agriculture. Mixtecs replaced the Mexican farm workers who arrived during the last century because indigenous workers are more vulnerable and subject to hard labor and mistreatment from both growers and co-workers with higher status.

### *Mixtecs and Oxnard*

According to Oxnard's Mixteco/Indigena Community Organizing Project (MICOP), there are 20,000 indigenous Oaxacans in Ventura County. The 2010 California's Indigenous farm worker final report estimates that 17, 500 indigenous farm workers from 93 communities of Mexico inhabit Ventura County. According to the same study, more than half of Mexican indigenous migrants in California are Mixtecs.

Mixtec communities in Oxnard work both separately from other communities and often collectively as a pan-ethnic identity. This means that frequently the Mixtec migrant communities in Oxnard such as Santiago Del Rio, San Martin Peras, San Juan Mixtepec, San Francisco Higos, and others work collectively to organize festivals and other celebrations. One of these festivals is the annual Guelaguetza, an Oaxacan celebration that unites indigenous cultures of the state of Oaxaca. However, in addition to collective pan ethnic organizing, Mixtec communities embrace

their own hometown as a form of organization mainly because of community networks and civic participation. For example, hometown associations such as *Comite de Cooperacion of San Francisco Higos* only deal with matters regarding the San Francisco Higos community. However, communities still work together within a pan-Mixteco/Oaxacan identity in Oxnard.

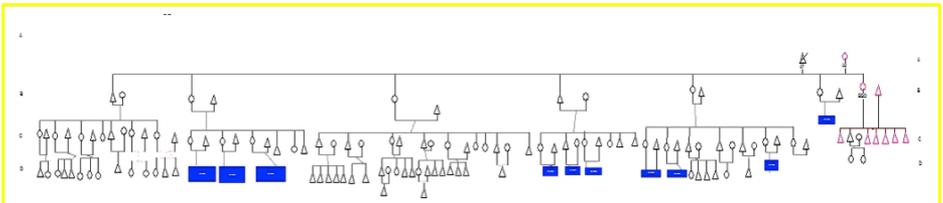
As Travis Du Bry points out in his study of Mecca, a new rural class structure emerges in the rural town which consists of those who hold major positions or occupations in the agricultural business hierarchy and the seasonal workers who work at the lower ranks of the industry (Dubry 2007). Oxnard's social structure is similar to Mecca's. It is divided by class, based on the type of work one does in agriculture (and sometimes out of it). Although Mixtecs in Oxnard occupy the lower ranks of the agriculture labor hierarchy, there are instances where Mixtecs experience upward mobility. According to Lynn Stephen, many Mixtec workers who settled after the Immigration Reform and Control Act of 1986 have managed to work their way up the agricultural labor hierarchy by acquiring better work positions. I explore this further in my case study of San Francisco Higos. I analyze how Oxnard's industrial agricultural economy affects the migrant experience of San Francisco Higos based on transnationalism, the household, employment, and education.

## **Ethnography of San Francisco Higos in Oxnard, California**

### ***San Francisco Higos: The Household***

The transnational migration process of San Francisco Higos is revealed through the household. The typical household of San Francisco Higos in Oxnard consists of four generations: "grandparents" (generation A), "parents" (generation B), "children" (generation C), and "grandchildren" (generation D). There are important differences within the household, which may include: migration status, education, and job. As an example, **Figure 1** is a genealogy of a nine-member household. Generation A is composed of grandparents who are usually over 80 years old.

Generation A were the first migrants who initially migrated within Mexico and then the males migrated to the United States as part of the Bracero Program. The grandfather in this genealogy died almost 20 years ago while the grandmother is living in Oxnard under the care of her sons and daughters. Generation B, the “parents,” is made up of those who typically migrated to the United States after the Bracero Program. Beginning in the 1970s and 1980s, they arrived as undocumented migrants. Many in this generation were granted legal residency after the 1986 IRCA. Some were able to bring their entire families to the United States. Generation C, which I refer to as “children,” are the second generation (born in the U.S.) and 1.5 generation (born in Mexico but brought to California as minors). Many of the young adults’ range in age from 20-30; the eldest people in this generation are approximately 40 years old. Generation D, “grandchildren,” is mostly composed of children under the age of 20. The majority of these children were born in California.

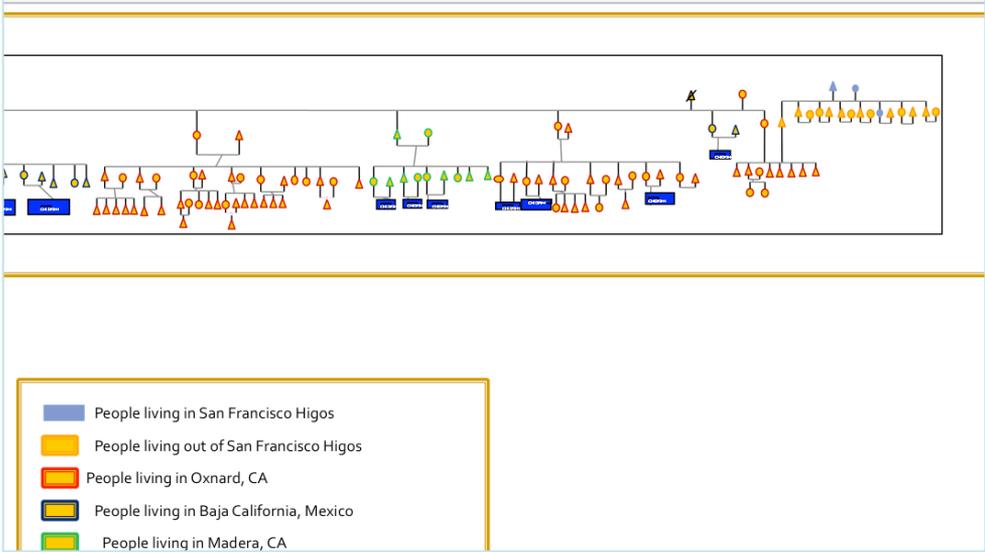


**Figure 1: The household.**

***San Francisco Higos: A transnational community***

San Francisco Higos is a transnational community dispersed throughout different parts of North America. **Figure 2** demonstrates transnationalism by showing the dispersed family members in two nation states. Most members of the extended family live outside San Francisco Higos, in two countries and different cities. For instance, a child who is part of generation D is most likely to have an uncle who lives in Gilroy, CA; the child can

also have a cousin in Madera, CA; and an aunt in Camalu, Baja California, Mexico. Only three members of an extended genealogy of six families actually live in San Francisco Higos. The rest live in the San Quintin Valley in Baja California, Mexico, and the northern and central coast of California in the United States.



**Figure 2: Community Clusters (partial genealogy)**

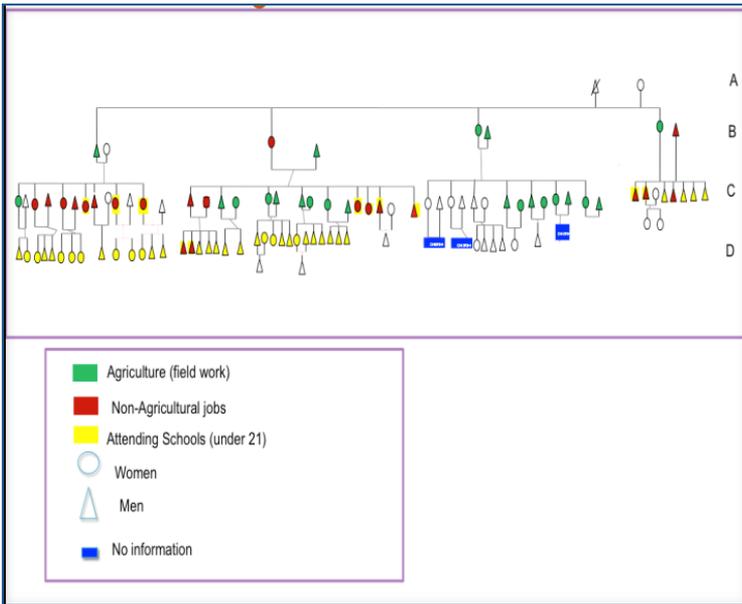
In Figure 2, the yellow icons with green outlines represent those living in Madera CA, the yellow figures represent people living in Baja California, and the yellow figures with red represent people living in Oxnard. For the purpose of this study, I focus on the people currently living in Oxnard, CA.



**Figure 3: From San Francisco Higos to Oxnard, CA.**  
**This map demonstrates the geographical route of migrants and the transnational connection of two communities.**

### *San Francisco Higos: Employment and Education*

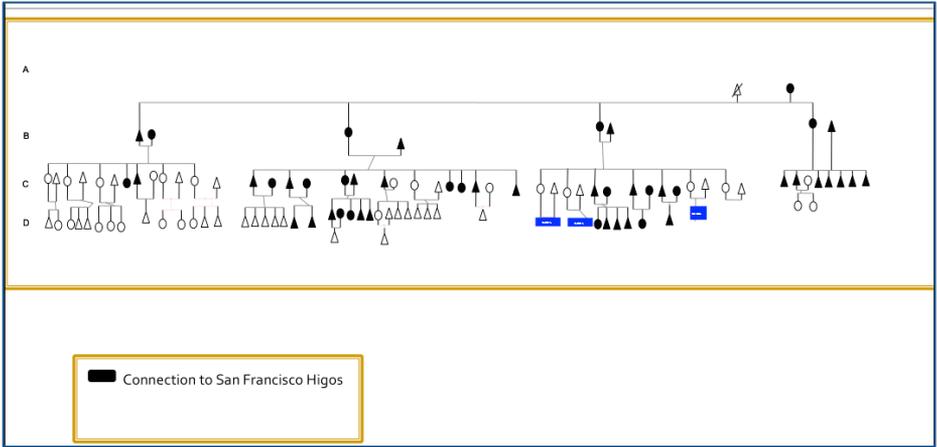
San Francisco Higos community members in Oxnard are changing. For instance, parents (generation B) arrived as agricultural laborers but the genealogy shows that they are starting to leave agriculture for other jobs such as landscaping, painting, trucking, and industry. One individual from generation B works at a local factory and the other one works as a truck driver. Some members of generation C (young adults and adults from ages 21-40) are still in agriculture but most have moved to other jobs. Some of them, especially those documented, seek educational attainment, finishing high school and pursuing a college degree. Everyone in generation D, who are primarily under 21 years, are all active in the education system and will most likely never work in agriculture.



**Figure 4: Socioeconomic Mobility**

Community members are still connected to the community of San Francisco Higos in Mexico despite living in Oxnard. This connection is maintained through owning land, building houses, contributing funds, and being politically active. These people attend local “fiestas” (patron saint, Christmas, and Virgin of Guadalupe) in both Mexico and the United States, and participate in the organization of the ceremonies through what is known as the *cargo* system. They continue to pay their dues as members of the community. **Figure 5** shows these connections. This group also includes children under 18 who are taken by their parents to the community when their parents are doing a *cargo*, a custom that could be described as a form of tax. In addition, one family in the genealogy in **Figure 5** (first family on the left) has only two people in generation C and none in generation D that participate in San Francisco Higos transnationalism. The majority of the members of this particular family are females who are married to men who are not part of the community. The chart illustrates that in the first two

families, starting from the right side in **Figure 5**, only male members and their families have a connection to San Francisco Higos.



**Figure 5: Connection to San Francisco Higos**

**Field Discussion**

***San Francisco Higos Socioeconomic Mobility and Transnationalism in Oxnard***

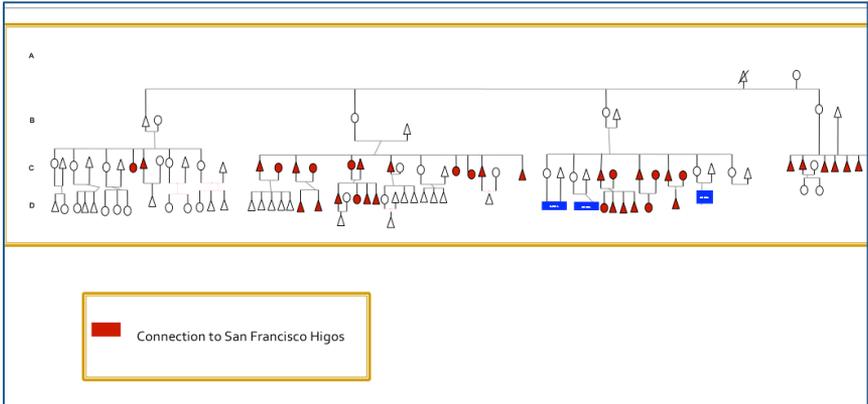
In December 2012 while I was in San Francisco Higos in Oaxaca, different adults approached me to inquire about my college degree and my professional plans. I was treated with great courtesy and respect. One man who was older than me used the formal “usted” while addressing me and another one asked me to dance with his wife in one of the community celebrations. Although I felt extremely uncomfortable, I came to understand the community investment in educational attainment through the display of admiration for college students like me. The respect older people give to college students is a demonstration of what Tara Yosso calls “community cultural wealth” - cultural assets and resources accumulated over time which eventually form capital

that supports Chicano/a students to achieve higher education (Yosso 2006). Moreover, in this case, cultural wealth in San Francisco Higos is demonstrated by the display of admiration of western educated college students. For indigenous communities like San Francisco Higos, higher education is a road out of poverty and marginalization. Therefore, my worth as a person and that of other San Francisco Higos' western taught educated members increases as we achieved higher education, but it also demonstrates the hopes and aspirations of an entire community.

Despite living in the United States and having a different socioeconomic status, San Francisco Higos migrants in Oxnard are still connected to the transnational community. This connection is maintained through traveling back to San Francisco Higos, networking with other community members, and creating transnational hometown associations in Oxnard. However, most family members that participate in San Francisco Higos transnationalism are males; as shown in **Figure 5**, most female community members do not participate in the community once they marry a non-community member. This demonstrates the continuation of a patriarchal *cargo* tradition in San Francisco Higos' transnational process. Moreover, according to an elder community member I interviewed in Oaxaca, the participation in the transnational community is a result of land. Owning land in San Francisco requires one to hold a *cargo*.

There is a connection between San Francisco Higos and the future generation of migrants that includes their education, socioeconomic mobility, and indigenous identity. School attendance in the United States is mandatory before the age of 18. Therefore, the majority of the younger generation will not need to toil in low paid jobs in agriculture. That fact alone indicates the possibility of achieving a higher socioeconomic status than the first generation migrants. The decision to attend college is based on various factors and is largely influenced by legal status and financial aid. As **Figure 6** demonstrates, young adults, mostly males, who graduated college, participate in transnational community. There are different factors that might influence this

decision, including owning hereditary land and therefore having the responsibility to fulfill *cargos* to maintain the land their parents granted them. Migrants, including the second generation, despite educational attainment and socioeconomic mobility, are still attached to San Francisco Higos through land ownership.



**Figure 6: Youth Connection to San Francisco Higos (includes children)**

***Rompiendo el Hilo, Cutting Strings: The role of Mixtec Younger Generation in Oxnard-San Francisco Higos Transnationalism***

As migrants’ socioeconomic mobility advances, the community expectations for expensive community celebrations increase as well. An older community member I interviewed in Oaxaca mentioned that community celebrations have been changing. There is an increasing lack of volunteers to organize these celebrations in Oaxaca, Mexico. A community celebration in the town of San Francisco Higos now costs around forty thousand dollars. To come up with this money certain people (usually 8-12 families) volunteer to provide the celebrations. For example, in San Francisco Higos, the Christmas celebration included a dance after the creation of candles in November with food, drinks, mass, decorations and musical entertainment. Moreover, at the December 23<sup>th</sup> to the 25<sup>th</sup> Christmas festivities, the main

celebration featured a rodeo, mass, dance, fireworks, and food for the entire community. For the community celebration in October 2012 to celebrate St. Francis in Oxnard, the people who volunteered acquired an acre of land on which to hold the celebration, paid for a Catholic mass, the musical entertainment, and food catering. Expensive community celebrations in San Francisco Higos in Oaxaca and Oxnard have increased and so has the prestige and stature of the members who coordinate these celebrations.

The increase of funds through transnationalism has brought internal community conflicts. Throughout its migration, the community was able to raise hundreds of thousands of dollars for community projects through sponsoring community games such as basketball and community monetary collection. The money collected is known as *el dinero del pueblo* or the people's money. As I talked to the same older community member, he mentioned the fear of corruption. There is uncertainty and disagreements about who should manage the money or where the money should be invested. I was part of a community meeting in San Francisco Higos where the major issue and discussion revolved around who is actually spending the money and on what, and what are the *cuentas* (transactions) made by community officials. This argument escalated to the degree that there was a physical fight outside the municipal offices.

I asked one man, a migrant who was in charge of organizing a celebration that traveled from California to Oaxaca, how these issues could be resolved? He replied: "los jovenes van a romper el hilo" - the youth will break the strings. He meant that the youth have the duty to serve the community their parents are from; they should look forward to finding solutions for these transnational conflicts (referred to as strings); and strive to maintain community civic participation. The youth of San Francisco Higos who reside in Oxnard, males and females, have an immense and important *cargo* on their backs: to maintain traditional community participation in the midst of economic and social challenges created by transnationalism.

San Francisco Higos young adult organizations in Oxnard are creating new forms of organization to engage younger generations in the civic responsibilities of the community and manage the community funds. For example, young adults are raising funds to cover the costs of community celebrations. Community celebrations are usually done through *Mayordomias* that are in charge of organizing four-day long festivities in San Francisco Higos. Due to the lack of volunteers for *Mayordomias* in Oaxaca, the youth raised funds to cover the costs of the celebrations. Also, young adult organizations are trying to include women. Traditionally, women in the community have participated through domestic work at celebrations but there are few women (or girls) in youth organizations. Research to explain the limited political role of young girls in transnational San Francisco Higos is needed to understand this reality. In addition, young adults are planning to fund scholarships for children and medicine for the elderly back in San Francisco Higos. Some of these youth members have created a corporation based in Oxnard to manage the funds of San Francisco Higos. These new organizational methods have led to disagreements with older community members about expenditures, monetary investments, and community projects. Although many of these youth do not speak *Mixteco*, they are trying to preserve and modify their traditions influenced by past family generations and to be more inclusive.

## **Conclusion**

Migration to California has been historically driven by agriculture. Throughout the process of settlement in their new home, migrants shape their social and political space. This is affected by both social and economic factors that include community participation and upward economic mobility. Once workers abandon agriculture, the industry needs to rely on new migrants to provide the labor needed for stable production. In the last decades, agriculture has been the major pull factor for Mixtec migration to California because of its increasing demands for laborers. Mixtec migrants arrive in California rural communities

heavily populated by Mexicans and become the next ethnic replacement in California's agriculture.

The transnational formation of San Francisco Higos is an example of a changing structure of a Mixtec migrant community in Oxnard, California. Members of the community have achieved socioeconomic mobility and although living in Oxnard, have not lost traditional customs and patterns of civic participation. The socioeconomic status of the next generation of San Francisco Higos migrants, whether born in the United States or not, is altering the structure of a transnational community. This generation is creating new organizations to contribute to the transnational process of San Francisco Higos. They continue to live in Oxnard but do not work in agriculture; however, they participate in San Francisco Higos primarily because they are expected to inherit their parents' lands. San Francisco Higos migrants in Oxnard, California have demonstrated a desire to maintain cross-generational connection to their home community and struggle to sustain transnational community.

## **Future Research**

Several questions arise from this case study. What are the consequences of San Francisco Higos upward mobility? One approach to answering this question is to do a comparative analysis of other Mixtec communities in Oxnard. Other questions might focus on the factors that influence transnational formation and who forms it. I mentioned gender roles in civic participation but more research is necessary to explore the role that gender, along with ethnicity, race, and ideas about masculinity play in Mixtec transnational communities. Moreover, what factors define indigeneity? Is it language, ethnicity, land, traditions? What is the role of socioeconomic mobility, education, and transnationalism in the formation of indigenous identity in younger generations?

The youth of San Francisco Higos have particular ways to embrace their indigenous identity. They base it on the political and economic structures of the transnational community. San Francisco Higos younger generations are reshaping the community's

indigenous traditions and the future of the community depends on them. More research is necessary to explore the identity formation of second-generation youth within Mixtec transnational communities. Could an indigenous community sustain both socioeconomic mobility and communality? What do these changes tell us about indigenous identity? This San Francisco Higos case study has shown the need for additional in-depth kinship analysis and critical field studies of Mixtec migrant populations in California's rural communities like Oxnard, California.

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To all migrants that transformed my life.

# Modeling Fluid-Driven Induced Seismicity

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## Abstract

*Understanding how fluid injection and hydraulic fracturing activity induce microearthquakes is paramount in determining the potential dangers, and quelling public fears where the risks are minimal. After a review of the relevant literature on microseismic imagery, problems in the interpretation of seismic data, and new statistical approaches to data processing, this paper proposes one way of constructing a numerical model of fluid-driven seismicity to grapple with the ambiguous relationship between the fluid and geo-mechanics driving seismicity. The model has the potential to project the spatio-temporal distribution of seismic events, in addition to their magnitudes. Locating induced seismic events within constrained confidence intervals, calculating out the focal mechanisms, and collapsing the hypocentral clouds, as suggested in this discussion, offers a model that may show the existence of subsurface structures creating the seismic events.*

## **Introduction and Literature Review**

Fluids moving through the solid earth have the power to break up rock and induce earthquake activity from the smallest scale to magnitudes great enough to cause minor damage to building structures. Artificially injecting fluid/water into the shallow crust has been done extensively by various industries for decades, sometimes creating smaller magnitude induced seismic events. Since the early 1900's, various industries have been artificially injecting fluid into the shallow crust for waste removal and to tap new energy resources (S.C. Maxwell et al., 2010). Today, the most commonly recognized proprietors of this technology are the petroleum/gas and hydrothermal industries, who utilize both fluid-injection and hydraulic fracturing (hydrofracking) techniques to tap the Earth for energy resources and to eliminate waste. These activities also have the potential to create induced seismic events at the microseismic scale ( $M < 2$ ), rarely ever being strong enough to be felt by people, but nonetheless, raising public concerns about potential earthquake damage. Earthquakes of this scale are both a byproduct of human (and in some cases natural) activities, and a key source of knowledge about the geological structure and composition at depth.

Microseismic imaging of subsurface structures has been used since the 1970s, primarily by the geothermal industry, to monitor fracture networks produced by fluid injection activity. Microseismic monitoring had not been employed by the petroleum/gas industry until more recently, particularly in the past several years as they have adopted the use of steam injection and hydraulic fracturing (S.C. Maxwell et al., 2010). Presently, microseismic monitoring in industry is done by two methods. The first is with downhole sensors in observation wells, and in close proximity to the treatment (injection) well, allowing for the best reduction in attenuation and background noise. More commonly, microseismic monitoring is done with surface level, offset sensors. The earliest use of microseismic imaging/event location was in geothermal hydraulic fracturing projects in New Mexico at Fenton

Hill and the San Juan basin, both using single downhole sensors. These two projects faced the problem of producing instruments sensitive enough for detecting microseismic signals, and developing the computational means of locating and mapping the events. (S.C. Maxwell et al., 2010)

Earthquakes are generated by the movement of rock along fault planes. These fault planes have orientations in space defined by their strike and dip. The strike details the cardinal direction along the surface that the fault traces while the dip measures the angle from horizontal surface that the fault plane dips into the Earth. A third metric, fault rake, describes the relative motions of the two sides of a fault as an angle. The combination of strike, dip, and rake are what make each fault plane unique.

When seismic slip (earthquakes) occurs along fault planes, a vast amount of energy is released. Much like a rock hitting a pond, the shock sends waves out from the fault plane that travel at distinct velocities through the rock layers beneath the Earth's surface. Each layer has its own seismic wave velocity due to compositional and density differences, and those velocities gradually increase with depth. Seismic waves are also broken up into different types, or phases. P waves are transverse waves where the ground is forced to oscillate parallel to the direction of wave motion. S waves exhibit oscillation perpendicular to the wave travel direction. These are the body waves, distinct from the surface waves (Love and Rayleigh waves) that occur as seismic energy passes through the Earth's surface, and are what typically cause earthquake damage.

Seismometers/geophones record these waves from the ground motion at the station location in terms of displacement, velocity, and acceleration. The rotated seismograms produced from this motion indicate the epicentral (along the surface) locations of the earthquakes, as well as the different phase velocities and arrival times, dependent upon having prior knowledge of the velocity structure of the region. The shapes and amplitudes displayed on a seismogram (waveforms) are like

unique signatures for each earthquake-station pair. These waveforms reveal critical pieces of information that allow seismologists to extrapolate backwards to the source mechanics, the orientation of the fault plane in space. Different combinations of strike, dip, rake, distance, and depth will produce different waveforms.

Microearthquakes, being produced on relatively small fault planes, are fast slip events that produce higher frequency waveforms compared to the large earthquakes usually studied. As such, there have been many studies done to devise methods to process the unique microseismic data. Aside from needing specially sensitive short period geophones, microseismic data also requires a change from the known methods used for larger scale (long period) earthquakes to those more suitable for microseismic events (short period data). Junlun et al. (2011) devised their own methods of determining the focal mechanisms and depths of smaller earthquakes using waveform modeling. Waveform phases and amplitudes were matched between synthetic and observed seismograms for both S and P waves using the Green's function, with the  $L_2$  norms, first arrival P wave polarities, and S/P amplitude ratios as criterion for matching. Their method uses a one dimensional velocity model, and data was tested from a 5-station network with both surface and borehole sensors to compare. The waveform matching produced consistent focal mechanisms throughout the 40 events examined, fitting with local stress measurements.

The methods of interpreting seismic data from fluid sources have evolved a great deal in the past few decades as computers have become more advanced. The challenges of microseismic imaging stem from ambiguities in our understanding of the relationship between the injected fluid and the geomechanical responses, as well as not knowing the confidence or accuracy in event locations. However, research on both natural and industry cases of fluid-driven seismicity have proven invaluable for increasing our understanding of the mechanics involved. One

possible example of naturally occurring fluid-driven seismicity is found in Vosges Massif region of France, which has a long history of seismic activity in an otherwise stable tectonic regime. The region has been seismically monitored since 1962, and Audin et al.'s (2002) inquiry into the existing data revealed patterns in the migration of seismicity through the region in time, suggesting that earthquake activity is not being produced by tectonic forces.

The data was processed by relocating the recorded seismic events using Audin et al.'s hypocentroid decomposition technique, removing much of the variability in the wave arrival times due to heterogeneity in the crust's velocity structure, and increasing the precision of relative locations to within 250 meters. This revealed that the events were clustered about a 3 km long North-South trending plane. Over the time span of the data, earthquake activity was found to exhibit a pattern of southward migration, with events intermittently stalling and building up in one location. The migration of the seismicity apparently follows the movement of water, which ceases when an impermeable barrier is encountered, and resumes again when the barrier is broken through a sufficient increase in pressure. This natural source of fluid-driven seismicity behaves similarly to artificial hydraulic fracturing, as performed by the petroleum industry.

Hydraulic fracturing (hydrofracking) of the Earth's upper crust works by injecting a water based fluid several kilometers down a borehole at high pressure. The pore fluid pressure is great enough to force fluid to migrate through the pores and cracks within the rock, opening up new pathways/fractures. This allows other fluids present in the subsurface, such as oil, to migrate out of the rock, or for hot water to circulate back up to the surface for hydrothermal energy production. In the case of a non-linear (spherical) pore pressure diffusion, Shapiro (2009) developed a working mathematical model to describe pore pressure relaxation and hydraulic fracturing induced seismicity. Using the Barnett Shale gas reservoir in Texas as a site of study, Shapiro (2009) derived several important relationships between pore pressure and

the local stress. The triggering front of maximum pore pressure, producing the most seismicity, is represented as:

$$r_t \propto (D_0 Q_0^n t^{n(i+1)+1})^{1/(3n+2)}, \quad (1)$$

in the case of nonlinear diffusion. When seismicity is assumed to be produced by a linear opening of cracks within the rock (hydraulic fracturing controlled), with a bottom pressure greater than the minimum principal stress, we can define the half length of the fracture with respect to time with the relationship:

$$r_f(t) = \frac{Q_i t}{4b_f C_L \sqrt{2t} + 2b_f w}, \quad (2)$$

This is in contrast to the linear diffusion dominated case of induced seismicity:

$$r_t = \sqrt{4\pi Dt}, \quad (3)$$

These relationships are critical for understanding the temporal changes in an injection site and understanding how microearthquakes are generated in hydrofracking.

Further insight into the relationship between the fluid and geomechanics in the production of microearthquakes can be found by looking at examples of fluid injection induced seismicity, where the pore pressures are too low to open up fractures. When the fluid injection begins, the pore pressure rises first at the injection point, and then radiates outward as the fluid begins to migrate through the rock. Assuming a homogeneous medium, the field of maximum pore pressure travels outward from the injection point as a spatio-temporal function. At some distance and time from the initiation of injection, the rock experiences maximum pore pressure, and thus maximum seismic activity. However, following

the termination of fluid injection, seismicity still continues, as the maximum pressure field continues to disperse through the rock.

Based on this model of fluid injection induced seismicity, M. Parotidis et al. (2004) derive an equation to determine the distance from the injection point where seismicity ceases, at some time after the start of the fluid injection. The authors refer to this as the "back front" of induced seismicity. The equation:

$$r = \sqrt{6 \cdot D \cdot t \cdot \left( \frac{t}{t_0} - 1 \right) \cdot \ln \left( \frac{t}{t - t_0} \right)}, \quad (4)$$

describes the 3-dimensional radial distance of the maximum pore pressure perturbation for a given time  $t$ . Post-injection seismicity can be modeled with the use of Parotidis et al.'s (2004) back front equation without requiring knowledge of the flow rate or pressures, so long as the initial time is known or estimated.

In the pursuit of better models of induced seismicity, and the underlying structures they reveal, various statistical methods have been developed to process the microseismic data. One such method is the construction of confidence ellipsoids which can represent the uncertainty of earthquake locations in 3D space. R.H. Jones and R.C. Stewart (1997) tackle the problem of resolving structures from clouds of seismic events, which can be very difficult to discern by eye. They employed a technique that uses confidence ellipsoids and collapses the event locations into the simplest form possible.

Jones and Stewart (1997) show that the uncertainty in earthquake hypocentral locations can be used as a guide for processing seismic data from earthquake clouds when systematic errors have been removed and events with the correct station coverage have been prioritized. The collapsing method they developed moves hypocentral locations within the bounds of their location confidence ellipsoids to points where they intersect with the confidence ellipses of neighboring events. In this way, the

hypocentral locations get grouped closer together, defining the common fault structure generating the earthquakes, when present. This works primarily when uncertainty ellipsoids overlap with low confidence intervals.

Their collapsing technique is highly valuable, as it does not rely on visual inspection of the data to work, and omits very little data (only events falling outside of the defined confidence limit), as each event is treated as an informative piece of the picture. M. Fehler et al. (2000) sought to expand upon the progress of such collapsing algorithms, while simultaneously using their "Joint Hypocenter Determination scheme." The technique allows for the use of travel-time data directly, rather than derived hypocenters. This makes their method easier to integrate into existing earthquake location/velocity codes. Fehler et al.'s (2000) method differs from the prior models, in that it relies on uncertainty spheres surrounding individual events, as opposed to the ellipsoids used in the "collapsing method," with the error limitations remaining much the same.

## **Methods for Mapping Fractures near Fluid Injection Stimulated Wells**

To construct a computer model which can process microseismic events to determine event locations and, ultimately, be able to map out fractures in the vicinity of fluid injection stimulated wells, data from well logs must be obtained from one or more sources with an appropriate seismic network. Preferably, logs should be obtained from three-component downhole sensors to avoid issues with poor signal:noise ratios. The velocity structure of the chosen area must also be determined, either directly from data derived from calibration shots, or after inversion of the data.

Hypocenter locations and station residuals can be determined using Dr. Chen Ji's inversion techniques (2011), after proper conversion from long period to short period based calculations. This will be done through methodically applying the

inversion techniques to progressively higher frequency earthquake events, adjusting the calculations and parameters as needed. Inversion is to be done first with bandpass signal processing to remove the instrument responses and produce the initial velocity and acceleration seismograms. The seismograms will be used to pick the P-wave arrival times. Then, computations of the Green's function for the seismograms can be made.

Moment tensors can be calculated before undergoing waveform inversion, and producing the full synthetic seismograms. The linearized inversion method of Baisch (2006) may also be attempted. Synthetic seismograms and a grid search approach can be utilized to work out the focal mechanisms (rake, strike, dip and depth) of the seismic events. The grid search approach looks at a group of stations and finds the best fit within a certain seismogram length for both the observed and synthetic filtered seismograms that suit all three components of all seismic stations used for a single event. The earthquakes can be treated as point sources, since event magnitudes less than 2 typically have very small fault lengths.

For the study of large numbers of induced microseismic events, it will be necessary to collapse the hypocenter cloud to discern fracture planes. This can be done with Michael Fehler et al.'s JHD collapsing method (inversion inclusive), defined by the equation:

$$\sum_{ij} R_{ij}^2 + \lambda \sum_j C_j^2 = \sum_{ij} \left\{ \left( \frac{t_{ij}^{pm} - t_{ij}^{pe}}{\sigma_{ij}^p} \right)^2 + \left( \frac{t_{ij}^{sm} - t_{ij}^{se}}{\sigma_{ij}^s} \right)^2 \right\} + \lambda \sum_j \sum_k \{ (x_{jk} - x_{jk}^{cm})^2 \} \quad (5)$$

The first term includes the iterative inversion process, while the second is used to collapse the event clouds. Using a collapsing method to constrain event locations will also require a method of calculating the error/uncertainty in event locations. The variances,

for the JHD method, should be expressed as confidence spheres. R.C. Stewart's (1997) original collapsing method can also be applied here, but will lack the integrated functionality of the JHD collapsing method.

Once the code for determining event locations, and collapsing them to determine structures has been compiled, a larger spatio-temporal model of fluid-injection and hydrofracking induced microseismicity can be constructed to fit the data set (and, eventually, a wide range of data sets). This model will tie together both the fluid and geomechanical processes governing the distribution of seismic events, allowing for reconstruction of the spatio-temporal distribution, and even magnitudes, of microseismic events with given input parameters. M. Parotidis et al.'s back front seismicity model can be used as a guide, being governed primarily by the diffusivity:

$$\frac{\partial p}{\partial t} = D \cdot \nabla^2 p \quad , \quad (6)$$

the pore pressure front (3), and the radius of maximum pore pressure (4) equations. It would be an ideal model to emulate, given the minimal requirement on input parameters. The model can also be made to characterize event magnitude spatio-temporal distributions, following Sebastian Hainzl's example (2004), here being applied to induced induced fluid migration as opposed to natural fluid movement.

## Conclusions

The current models are still limited by a lack of understanding of how the fluid mechanics and geomechanics work together to produce earthquakes, and leave much room for improvement in forward modeling. The difficulty in calculating the error in locating microseismic hypocenters also limits our ability to apply the data to mapping geological structures. The model proposed here aims first to be able to faithfully reproduce

the observed distribution of seismic events at a particular site, then grow to be applicable to a much broader range of areas. These models are useful not only for characterizing the potential yields and benefits of fluid injection and fracking, but also for improving understanding of the complex relationships between the forces creating the microearthquakes. This may also extend the working knowledge of what hazards may or may not be present due to hydrofracking.

Monitoring of microseismic data is rapidly becoming a key tool in the productivity of hydrothermal companies and petroleum companies. Where American oil companies are concerned, it has been partially responsible for a multifold increase in oil production, and is the driving factor behind horizontal drilling success rates rising close to over 85%. This is good where the environment is concerned, as it means far fewer instances of wasted drilling efforts, and less impact on the environment. Improving models of fluid-driven microseismicity will become essential as industry moves closer to being able to monitor well operations in real time by listening to faint crackling and popping of microearthquakes beneath the surface. Drilling operations can begin to react quickly to changes, avoiding drilling or pumping water into potential hazard areas, and possibly even preventing the injection of harmful chemicals directly into the water table.

While the research plan outlined here focuses on earthquake locations, it will also be beneficial to investigate further the focal mechanics and stress changes of fluid-driven micro earthquakes to understand more about the local stress changes and energy release. Relatively little work has been done in this area, but it is important for understanding the local stress regime, a key component in local hazard analysis.

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# The Effects of Parasitic Infection on Fertility Rates of Tsimane Women

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## Abstract

*Parasites exert costs on their hosts, necessitating tradeoffs to accommodate for lost resources. As a consequence, parasitic infection in many species is associated with reductions in reproductive and somatic effort, with the potential for impacts on host fitness. Human offspring require substantial parental investment. However, few studies have examined the impact of parasitic infection on human reproduction. This project examines whether helminth infection is linked to fertility rates in women from a group of forager-horticulturalists in lowland Bolivia who experience a high prevalence of parasitic infection, through a life history theory framework. We examine conception rates in 280 women, 57.5% percent of whom were infected with hookworm, a common intestinal helminth. Data show that women infected with parasites have an odds-ratio of 0.49 of conceiving in a given year, relative to uninfected women. Our results suggest that helminths reduce conception rates in this natural fertility population, consistent with a significant cost of helminth infection on fertility.*

## Introduction

Parasitic infection has influenced many of the reproductive tradeoffs seen in human hosts. Throughout human evolution, humans have had an intricate relationship with the parasites and pathogens with which they are in constant contact. As humans have evolved, so have their parasites and pathogens, along with the mechanisms that help parasites stave off host responses (Thomas, 2012). It is because of this complex relationship that more research needs to be devoted to understanding the behavioral, developmental, and reproductive strategies executed by hosts in the presence of parasites and pathogens, especially in terms of how these infections influence their hosts. Specifically, this paper employs the theoretical framework of life history theory to examine the complex interactions between humans and intestinal parasitic worms (helminths), and investigate how parasitic infection affects fertility rates in women.

Life history theory proposes that natural selection has shaped organisms to make strategic allocations between growth, body maintenance, and reproduction for the ultimate purpose of maximizing reproductive success in the presence of environmental challenges (Stearns, 1992). Both females and males make energetic tradeoffs when investing in reproduction. For males, these tradeoffs often take different forms from their female counterparts, as each sex has different initial and parental investment strategies when it comes to their offspring. Males for the most part only have to contribute energetic allocation to copulation for short periods of time, whereas females must make energetic allocations to gestation and lactation for prolonged periods.

Allocations to reproduction are further complicated in the presence of harmful agents due to the tradeoffs organisms must make between reproductive efforts and body maintenance. Additionally, organisms must make tradeoffs between not only current and future reproduction but also the quality and quantity of their offspring. Moreover, parasitic infection is often associated

with heavy fitness costs on hosts due to exploitation of energetic resources. Therefore, we expect that certain costs of parasitic infection will affect the reproductive strategies and, consequently, fertility rates of women in specific types of environments.

## **Literature Review**

### ***Life History Theory***

Life history theory can best be explained by comparing it to the First Law of Thermodynamics. The First Law of Thermodynamics states that energy can neither be created nor destroyed and that all the energy that exists can be transformed from one shape into another. This concept can be applied to the energy that a body possesses and maintains throughout its lifetime. The body's energy can be distributed between three energetic categories: growth (height, muscle mass), reproduction (gestation, lactation), and body maintenance (immune responses, tissue repair). Because an organism is limited in the amount of energy it has, a body must allocate its resources strategically to maximize reproductive success.

In this study, we are evaluating the life history choices of a female human host in terms of her reproductive strategies in the presence of parasitic infection. Every event in an organism's life is time dependent and thus the tradeoffs between the distributions of resources to growth, maintenance, and reproduction is of crucial importance (Hill & Kaplan, 1992; Levins, 1968). For females, the tradeoff between reproduction and body maintenance, in the face of infectious disease, is often intensified with additional tradeoffs between current and future reproduction and the quality and quantity of offspring (Abrams & Miller, 2011).

### ***Reproduction and Body Maintenance Tradeoff and Attuned Immune Responses***

Reproduction is costly and time consuming. Consequently, reproductive efforts will seize energetic resources from expendable resource usage systems such as the immune system (Abrams &

Miller, 2011). Yet, in times of disease, infection, or strenuous conditions, depletions of energy from the immune system can have detrimental effects on the health of organisms. From a life history perspective, depending on how much investment has gone into reproductive efforts, a body should react with different strategies when infected with disease. If a large amount of investment has gone into reproduction such as later stages of pregnancy where substantial time and effort has been invested into a fetus, an infection should not prevent the continuance of the pregnancy (Behnke, Barnard, & Wakelin, 1992). In opposite circumstances, when a small amount of energy has gone into reproduction, such as the beginning weeks of pregnancy, an organism would benefit by terminating the pregnancy, to invest more resources into fighting off infection and reproducing at a later stage (Vitzthum, 2008; Peacock, 1991). Vitzthum, Thornburg, & Spielvogel (2009) found that in rural Bolivia women undergoing arduous seasons of work load and food shortages, had higher levels of early pregnancy loss. This suggests that females have adapted mechanisms to adjust how much investment they will make per reproductive effort depending upon environmental cues.

Pregnancy is a complex period of time in which a woman invests energetic resources into offspring (gestation), while at the same time tries to balance the remaining energetic resources for her own body. After the fertilization of a female's ovum, the first obstacle an embryo faces is successful implantation. Because an embryo has half the genetic makeup of the father and half of the mother, it becomes genetically distinct in the mother's uterus and faces the danger of attack from the mother's immune system. Therefore, an attuned immune response on the mother's part has an important impact on successful pregnancy. In the most advantageous circumstance, a woman's body will accurately recognize the fetus as not harmful and allow implantation. In unfavorable circumstances, a woman's body will not be able to make this distinction and incorrectly attack the fetus, usually through maternal inflammatory responses. Clancy et. al. (2013), found that inflammation processes often lead to ovarian function

suppression. The variety of immune responses that use inflammatory mechanisms in the mother's body which vary in different environmental settings, often have adverse pregnancy outcomes such as premature delivery, preeclampsia, and pelvic inflammatory disease (Ness, 2004).

As counterintuitive as it sounds for a mother to destroy her offspring, her immune system has been programmed to produce lymphocytes that accurately destroy cell markers not similar to her own. She had not previously been exposed to cells similar to what her offspring would produce, and thus her immune system is not prepared for the new genetic makeup of her offspring. Yet a women's physiology can be prepared to expect future offspring, in the form of a suppressed immune system following ovulation (Ellison, 2001). Many studies have found that increased reproductive efforts will lead to the suppression of the immune system and parasitic resistance in many species (Lutermann, Medger & Horak, 2012; Nordling, Andersson, Zohari, & Lars, 1998; Sorci, Clobert & Michalakis, 1996; Festa-Bianchet, 1989).

Another way in which women's bodies also modulate fertility is through the regulation of ovarian steroids. Ellison (2003) examined how progesterone and estradiol salivary levels, key ovarian steroids that function in aiding implantation, were lowered during low levels of energy, such as during weight loss or recreational exercise. However, elevated levels of follicular progesterone, sometimes stimulated through stress stimuli or ovarian malfunction, are also linked to early pregnancy loss (Vitzthum, Spielvogel, Thornburg & West, 2006). Hence an accurately attuned immune response and balanced female reproductive system are vital for successful fetal implantation and pregnancy.

### ***Current/Future Reproduction Tradeoff and Quality/Quantity of Offspring Tradeoff***

In certain environments, the amount of stress an organism is under will alter the distribution of resources it is currently employing, leading to a tradeoff between current and future

reproduction (Pianka, 1976). For example, in an ideal environment, an organism would be able to balance body maintenance and reproductive resources, and if sexually mature, begin the process of investing more resources into reproduction. Yet, in an environment heavily impacted by harmful diseases, it would be in the organism's favor to alter its resource allocation to body maintenance and postpone reproduction. Rather than exhaust resources into current reproduction, a body should invest maximally in fighting infection, to fully recover and reproduce in the future. Nevertheless, recent studies have found that this course of action might not be what host bodies undertake with parasitic infections.

Disease type and diversity have recently been linked to the reproductive efforts of women. With an increase in the diversity of human diseases (for example, helminth infection), the fertility rates of women increase due to the morbidity and mortality rate associated with infection (Guegan, et al., 2001). An increase in parasitic infection or pathogen load will cause an organism to invest more resources toward reproduction because of an underlying risk of dying before being able to reproduce as well as a way to lessen the cost of parasitic infection on offspring mortality (Agnew, Koella & Michalakis, 2000; Polak & Starmer, 1998). In this instance, the proximate cause of infection will lead an organism to a reaction norm in which reproducing earlier maximizes reproductive success. The organism will invest in producing as many offspring as possible, in the likelihood of at least one of the offspring surviving to pass on its genes.

Forbes (1993) looked at how specific types of parasitism affect a combination of future and current reproduction. A parasite which is slow to develop in the host but later reproduces and multiplies rapidly can be thought of as affecting future reproduction more than current. With this type of parasitism, it would be beneficial for a host to invest in current reproduction efforts and produce a lower quality offspring rather than never reproduce. If a host were infected with a type of parasite that

affects current reproduction more so than future reproduction (a parasite that quickly develops within a host for a short period of time and then leaves the host), it would be beneficial for the host to distribute resources to body maintenance and continue its reproductive efforts as if it were not parasitized. The host would either invest in current reproduction or wait to invest into future reproduction depending on other energetic constraints and environmental cues.

Yet investing in current reproduction comes at the cost of reduced future reproductive efforts as well as survival (Bell, 1980). Hanssen, et al. (2005) found that in female common eiders, a long-lived bird, an increase in incubation demand (a larger clutch size) did not lead to negative effects on current reproductive effort, but did have a long-term fitness cost on future fertility. Gustafsson & Sutherland (1988) also observed that enlarged clutch sizes were associated with lowered fecundity in subsequent years. But in some cases, not investing in current reproduction, or conserving energetic resources for future reproduction, is beneficial for an organism. In water fleas, the accumulation of energy reserves produce higher levels of fertility following years of food shortages (Goulden & Hornig, 1980). As a result, energetic tradeoffs between current and future reproduction affect how organism invest into the reproductive strategies they employ.

Another feature of this complex relationship in humans is a woman's choice to reproduce at a later age and how that interacts with the desire for capital resources, which in developed countries is occasionally linked with the eradication of parasitic infection. A study by Bleakley and Lange (2009) found that with the eradication of hookworm infection there was a significant decrease in fertility rates (in the southern United States), explained by the quality-quantity model. The quality-quantity tradeoff model describes how organisms allocate resources into offspring, either by investing all their resources into one larger offspring or investing them into many smaller offspring. With a decrease in the burden of parasitic infection, women are able to choose to invest in later reproduction to increase the quality of their child by providing

better monetary resources to that one child rather than to increase the number of children they have throughout their lifetime.

In sum, the research literature suggests that parasitic infection may influence fertility through a variety of pathways. In the present study we test one of these pathways, examining the relationship between parasitic (helminth) infection and conception rates in Tsimane women, a natural fertility population that makes no conscious effort to regulate their fertility. Our study examines conception rates longitudinally, and examines whether women infected with parasites at an initial time-point are more or less likely to become pregnant in the following year.

## **Methods**

For this project we analyzed data already collected by The Tsimane Health and Life History Project at the University of California, Santa Barbara. The project began data collection in 2001 under the direction of Dr. Michael Gurven. The project continues to be a successful longitudinal study expanding research on ecological and evolutionary impacts on the health and growth and development of Tsimane people for many of the faculty and graduate students in the Anthropology Department at UCSB. The data used for this project were collected between March 2007 and February 2012.

### ***Participant Population***

The Tsimane Health and Life History Project (THLHP) is a panel study<sup>1</sup> designed to investigate the health, life histories, and ecology of the Tsimane people. The Tsimane are a forager-horticulturalist indigenous population located in central lowland Bolivia. They sustain themselves mostly through agriculture, fishing, hunting, and gathering. The Tsimane Health and Life History Project had been previously described in depth (Gurven et

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<sup>1</sup> A specific type of longitudinal study that collects data on the same individuals during specified times of a year, often for many years.

al., 2012; Gurven et al., 2008). Data for this project were collected from eighty-three Tsimane villages, covering an opportune range of environmental settings such as forests, rivers and market economy access. Tsimane living in the villages being surveyed are eligible to participate in the study. The THLHP research team works at collecting demographical, anthropological, and biomedical data from the Tsimane, while at the same time providing them with medical care.

The participants in this study were seen by the THLHP mobile biomedical team, which visited Tsimane villages annually from 2007-2012. The participants were given physical exams, and following on site analysis of fecal and blood samples, were administered medicines such as vitamins, antibiotics, and antihelminthics, as determined by the THLHP physician. Blood and fecal samples were collected from a total of 5,200 patients. Parasite identification in fecal samples has been described elsewhere (Blackwell et al., 2011). Out of those 5,200 individuals, 2,645 were female. To run the statistical analyses in this study, this number was reduced to incorporate only females between the reproductive ages of 15-45 on whom we had data indicating infection status the first year of visit and pregnancy status the following year. A total of 280 females fit this criterion.

### ***Statistical Analysis***

Data evaluated were collected over two consecutive years. In the first year, a count was given to the female participant if she was infected with a helminth (1 for infected, 0 for not infected), succeeded in the following year with another count if she had become pregnant (1 for pregnant, 0 for not pregnant). For this study, fertility was determined by a woman's pregnancy status (pregnant/not pregnant) regardless of helminth infection and month of pregnancy.

Two types of statistical models were run on the data collected. The first test consisted of a chi square test of independence. The chi square test evaluated the significance between the proportion of women who were pregnant and infected

with a parasite in our study against the proportion of women who in a natural setting would also be pregnant and infected with a parasite. The second test used a logistic regression model. The logistic regression analyzed the odds ratio of women with a parasitic infection becoming pregnant, based on the individual counts the women were given if they were pregnant and if they were infected with a helminth, controlling for age. The chi-square test was run both in R 3.0.1 and Excel, and the logistic regression model was run in R 3.0.1.

## Results

To test the hypothesis that helminth infection affects the fertility rates of women in a natural fertility environment, we ran a chi-square test of independence to evaluate the proportions of parasitic infection and pregnancy in our study to those expected in a non-experimental setting. Before this test was carried out, we calculated the counts assigned to women related to their pregnancy and helminth infection status. From these raw counts, the percent chance of conception was calculated relevant to helminth infection. Women without a helminth were 15.1% likely to become pregnant, as opposed to women with a helminth, who were 7.5% likely to become pregnant (**Figure 1**). In our study sample, 57.5% of women were infected with a helminth. These counts were further separated to incorporate the differences between age groups. Including the two age groups, women ages 15-30 were 26.7% likely to become pregnant without a parasite and 22.2% likely to become pregnant with a parasite; women ages 30-45 were 11.2% likely to become pregnant without a parasite and 4.5% likely to become pregnant with a parasite (**Figure 2**).

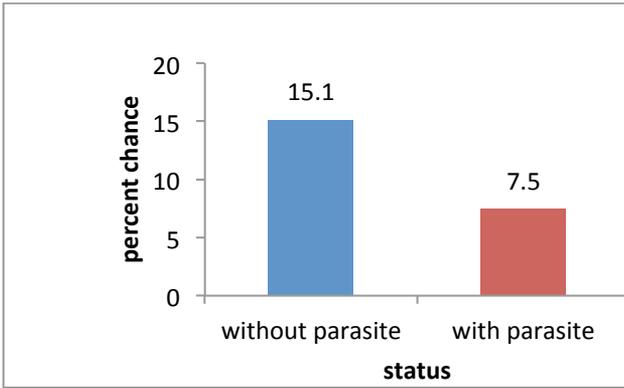


Figure 1. Percent chance of conceiving

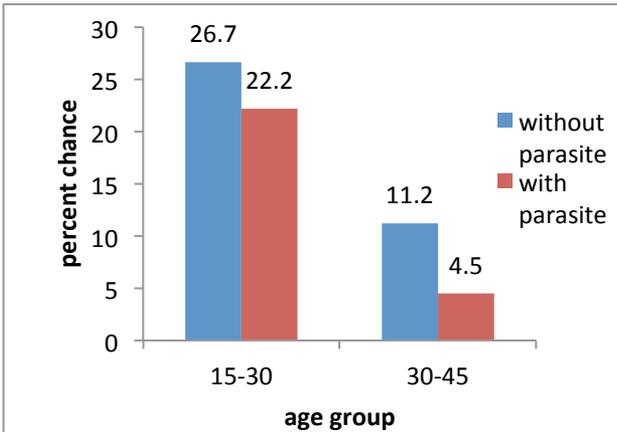


Figure 2. Percent chance of conceiving by age

For the chi square test of independence, expected frequencies were calculated in relation to the observed values recorded for pregnant/not pregnant women with/without a helminth (Table 1). The proportions of observed and expected status variables generated a significant interaction between pregnancy and helminth infection,  $\chi^2 (1, N=280) = 3.84, p = 0.04$ .

**Table 1. Chi-square test frequencies and test statistics**

Frequencies			Test Statistics	
Status	Observed	Expected		
Not Pregnant Not Infected	101	106.25	Chi-Square Test Statistic	4.21
Not Pregnant Infected	149	143.75		
Pregnant Not Infected	18	12.75	d.f	1
Pregnant Infected	12	17.25		
Total	280		p-value	0.04

Because both of the dependent variables being studied are discrete (they are either assigned a 1 if they exhibit the symptom and a 0 if they do not), a logistic regression model was used instead of a linear regression model (which uses continuous variables) to test for the interaction between helminth infection and fertility. The results from the logistic regression model in **Table 2** suggest that the maximum likelihood of women becoming pregnant with parasitic infection were about half (OR = 0.499,  $p = 0.09$ ). The p-value for the control variable of age was significant at a value of 0.0005, and the p-value for the helminth infection variable showed a considerable trend at 0.0857.

**Table 2. Logistic Regression Frequencies and Odd Ratio**

Frequencies			Odd Ratio (of Pregnancy)	
Variables	Coefficient	P-Value		
Intercept	0.88	0.2446	With Infection	~0.49
Age	-0.07	0.0005		
Helminth (Last Year)	-0.70	0.0857		

## Discussion

Our statistical analyses revealed similar results when examining the possible costs and/or benefits parasitic infection has on female hosts' reproductive efforts. The chi-square test of independence revealed a significant p-value of 0.04 between the relationship of two variables, parasitic infection and pregnancy in Tsimane women. However, the logistic regression model, when controlling for age, produced a marginal significant value of 0.09 in examining the probability of Tsimane women conceiving with a parasitic infection. From these results, parasitic infection seems to be decreasing the reproductive efforts of Tsimane women. However, previous research has found that Tsimane women have very high levels of completed fertility, with the total fertility rate of Tsimane women at 9.0 (McAllister, et al., in press). Therefore, helminth infection seems to be delaying reproduction, yet Tsimane women have many children by the end of their reproductive stages. We can speculate that parasitic infection is having some influence on current reproductive strategies in women that might be indirectly affected through other immunological response paths.

The logistic regression model revealed that the odds of women conceiving with a parasite were slightly less than half what they were without an infection. The results might be indicating that Tsimane women are employing a reproductive strategy of first recuperating somatic health and then investing into reproductive efforts, and as a result, reducing current fertility rates in the population (Hurd, 2001). The results suggest that the fertility rates of Tsimane women are affected by parasitic infection in a negative manner. Parasitic infection in Tsimane women is consistent with burdening the host with a cost (fighting of infection), rather than providing a benefit (increase reproduction outcome) (Gustafsson, Nordling, Andersson, Sheldon, Qvarnstrom, 1994).

## Conclusion

This study was an attempt to understand how Tsimane women optimize the allocation of energy between reproduction and longevity to maximize their own reproductive success. It incorporated life history theory to provide the theoretical framework into which we fit the development of life history tradeoffs, such as current and future reproduction and reproductive effort and somatic maintenance. This type of study offers a good foundation for analyzing life history traits. Because environmental settings are always changing and most populations will never face environments without energetic constraints, energetic tradeoffs imply that resources for one trait will often lead to fewer resources for another trait. Additionally, parasites are direct agents of selection that have significant influences in shaping traits (Thomas, Poulin, Guégan, Michalakis, & Renaud, 2000). It is important to examine the long-term effects of parasitic infection on hosts, as those effects will determine host fitness and generate the mechanisms hosts will develop in dealing with parasites. For example, if parasitic infection considerably reduces host fitness, we should expect selection to favor individuals that are effective at avoiding infection, either through behavior or genes. Therefore, evaluating the role of environmental cues and parasitic constraints on energetic tradeoffs can shed light onto the evolutionary history of the development of life history traits.

Our research data might have calculated a stronger relationship had our data pool been more complete. Some data points per women were incomplete or had missing values. For instance, some women were pregnant, yet their helminth infection values were missing. Therefore, we did not know whether or not they had had a parasite the previous year. When running the statistical analysis, missing data were considered, yet a more complete data set could have provided clearer results. Similarly, incorporating data regarding inflammation levels, reproductive cell levels, and other immunological response levels into this model,

might have shed light into how parasitic infection is influencing pregnancy and fertility rates.

As a follow up to this study, we would like to incorporate other data on the immunological and hormonal responses of Tsimane women in order to examine the mechanisms of reproductive suppression. Future research could more closely examine the development of specific life history traits, such as age at first reproduction, in the presence of parasitic infection or other heavy environmental constraints. From our study, one thing remains clear: parasitic infection and exposure plays a large role in the life history tradeoffs executed by a host. It is evident that in trying to learn how humans develop and evolve, research cannot exclude parasitic presence. Multiple theories in the study of biological anthropology could be enhanced and better understood by incorporating host-parasite relationships.

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# Working Towards a Numerical Counterexample to the Spira Conjecture

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## Abstract

*In his 1965 paper Zero-Free Regions of  $\zeta^{(k)}(s)$ , Robert Spira conjectured a relationship between the number of zeros of the Riemann Zeta function and the number of zeros of its subsequent derivatives. More recently, this relationship has been refined and Spira's conjecture has become suspect. Using techniques gleaned from calculus, linear algebra, and complex analysis, a series of Mathematica based programs are constructed that determine regions in which Spira's conjecture will most likely fail, and then test such regions.*

## Introduction

The German mathematician Bernhard Riemann was not the first to study the properties of the complex-valued function now known as the Riemann Zeta function,

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s} = 1 + \frac{1}{2^s} + \frac{1}{3^s} + \dots$$

but arguably he did garner it the most notoriety. In his 1859 paper *On the Number of Primes Less than a Given Magnitude* [Rie], Riemann discovered an explicit formula that outputs the number of primes less than a given real number. In that paper, Riemann's calculations show that the location of the zeros of the Zeta function controls the oscillations of primes around their predicted values. The zeros of Zeta come in two classes: the negative even integers form the class of trivial zeros, and any other zeros comprise the set of non-trivial zeros. Riemann's famous conjecture, now known as the Riemann Hypothesis, is that all non-trivial zeros have a real part equal to one-half. Pictorially, these points lie on a vertical line known as the critical line.

In the field of analytic number theory, mathematicians employ techniques from calculus to study number theoretic functions like Zeta. By answering questions about the derivatives of Zeta, for instance, insight can be gained into the behavior of Zeta itself. In the closing lines of his 1965 paper *Zero-Free Regions of  $\zeta^{(k)}(s)$* , the American mathematician Robert Spira conjectured that, for all  $k$ , one has

$$N_0(T) = N_k(T) + \left[ \frac{T \log 2}{2\pi} \right] \pm 1$$

where  $N_0(T)$  is the number of zeros of the Zeta function with imaginary part between 0 and  $T$ ,  $N_k(T)$  is the analogous counting function for the  $k^{\text{th}}$  derivative of Zeta, and the square brackets

denote the floor function [Spr]. Spira formulated this relationship based on numerical evidence computed for the first two derivatives of Zeta when  $0 \leq T \leq 100$ . Recently, however, evidence has been put forth that seems to invalidate Spira's proposed conjecture for higher regions in the complex plane, i.e., for larger values of  $T$ .

In the following sections, we detail a series of algorithms written in Mathematica<sup>1</sup> that, collectively, locate and test such suspicious regions. First, a method by which many derivatives of Zeta may be calculated efficiently is outlined. Then, the theory behind finding candidate values of  $T$  is explained. Next, a procedure for counting zeros of the Zeta function is described. Finally, future work is also summarized. Additionally, there is a final section containing the actual lines of code used to produce the data.

## **Numerically Computing High Order Derivatives**

Standard methods to compute any derivative of any function already exist in Mathematica. Generally, the problem one runs into is that as the order of the derivative increases, and as the given function becomes more complicated, the execution of these traditional algorithms becomes unfeasible. In this section, we detail a rapid method for numerically computing any derivative of any complex valued function up to any prescribed error. These computations will be necessary in subsequent sections of this paper, in which we compute many derivatives of the Zeta function.

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<sup>1</sup> Mathematica is a computational software program designed by Stephen Wolfram, the creator of the popular website Wolfram Alpha. Mathematica performs all of the same operations as Wolfram Alpha, and moreover is programmable to suit the users needs. In this paper it is used to handle a massive amount of iterative calculations that would be impossible to compute by hand.

Let  $C$  denote the complex plane,  $D$  some subset of  $C$ , and  $f: D \rightarrow C$  any meromorphic function. Fix some base point  $z$  in  $D$  (the value at which one wishes to compute a derivative) and let  $z_0, z_1, \dots, z_n$  be  $n+1$  distinct points around  $z$ . Define the matrix  $A$  by

$$A = \begin{pmatrix} 1 & z_0 & \frac{z_0^2}{2!} & \cdots & \frac{z_0^n}{n!} \\ 1 & z_1 & \frac{z_1^2}{2!} & \cdots & \frac{z_1^n}{n!} \\ 1 & z_2 & \frac{z_2^2}{2!} & \cdots & \frac{z_2^n}{n!} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & z_n & \frac{z_n^2}{2!} & \cdots & \frac{z_n^n}{n!} \end{pmatrix}$$

As it will be important later, we can prove that  $A$  is invertible by showing that it has a nonzero determinant. Specifically, since the determinant is linear with respect to any fixed column of a matrix, we have

$$\det(A) = \prod_{i=0}^{\infty} \frac{1}{i!} \det \begin{pmatrix} 1 & z_0 & z_0^2 & \cdots & z_0^n \\ 1 & z_1 & z_1^2 & \cdots & z_1^n \\ 1 & z_2 & z_2^2 & \cdots & z_2^n \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & z_n & z_n^2 & \cdots & z_n^n \end{pmatrix} = \prod_{i=0}^{\infty} \frac{1}{i!} \prod_{0 \leq i < j \leq n} (z_j - z_i)$$

The last equality follows from the fact that the matrix in the determinant above is a Vandermonde matrix. It is well established [Wei] that such matrices have nonzero determinants precisely when each of the terms  $z_0, z_1, \dots, z_n$  is distinct. Therefore, the determinant of  $A$  is the product of two nonzero numbers and is therefore nonzero itself.

Let  $h$  be some small real number; usually,  $h$  is smaller than  $1/100$ . Next, we define two vectors  $\mathbf{u}$  and  $\mathbf{v}$  by

$$\mathbf{u} = \begin{pmatrix} f(z) \\ f'(z)h \\ \vdots \\ f^{(n)}(z)h^n \end{pmatrix} ; \quad \mathbf{v} = \begin{pmatrix} f(z + z_0h) \\ f(z + z_1h) \\ \vdots \\ f(z + z_nh) \end{pmatrix}$$

Then, using Taylor's Theorem, we have

$$A\mathbf{u} = \begin{pmatrix} f(z) + f'(z)z_0h + f''(z)\frac{z_0^2h^2}{2!} + \cdots + f^{(n)}(z)\frac{z_0^nh^n}{n!} \\ f(z) + f'(z)z_1h + f''(z)\frac{z_1^2h^2}{2!} + \cdots + f^{(n)}(z)\frac{z_1^nh^n}{n!} \\ \vdots \\ f(z) + f'(z)z_nh + f''(z)\frac{z_n^2h^2}{2!} + \cdots + f^{(n)}(z)\frac{z_n^nh^n}{n!} \end{pmatrix} = \mathbf{v} + O(h^{n+1})$$

where the big-O notation means that all of the higher order terms of the Taylor series are bounded above by  $h^{n+1}$ . Since  $A$  is invertible, the previous equation implies that

$$\mathbf{u} = A^{-1}\mathbf{v} + O(h^{n+1})$$

Thus, to compute the  $i^{\text{th}}$  derivative for  $i=0,1,\dots,n$ , we pick out the  $(i+1)^{\text{st}}$  entry of  $\mathbf{u}$ , which gives

$$f^{(k)}(z) = \frac{1}{h^k}(A\mathbf{v})_{k+1} + O(h^{n-k+1})$$

Therefore, to compute the  $k^{\text{th}}$  derivative of  $f$  at  $z$  within an error of  $h^m$ , we choose  $m+k$  distinct points around  $z$  and compute  $A$  and  $\mathbf{b}$  as above.

Of course, if one wishes to compute a large order derivative very accurately,  $m+k$  can grow quite quickly. Thus, the last component of this algorithm that is necessary to automate is how the surrounding points may be generated. For the sake of

simplicity, the points are chosen so that they form a square grid centered at the base point. To be centered, our grid must have an odd number of points, but this restriction does not pose a significant problem because if one has to add more points to get an odd amount it only increases the precision of the calculation. Then, starting from the bottom left corner and advancing along the rows of the lattice of points, the  $j^{\text{th}}$  point is given by

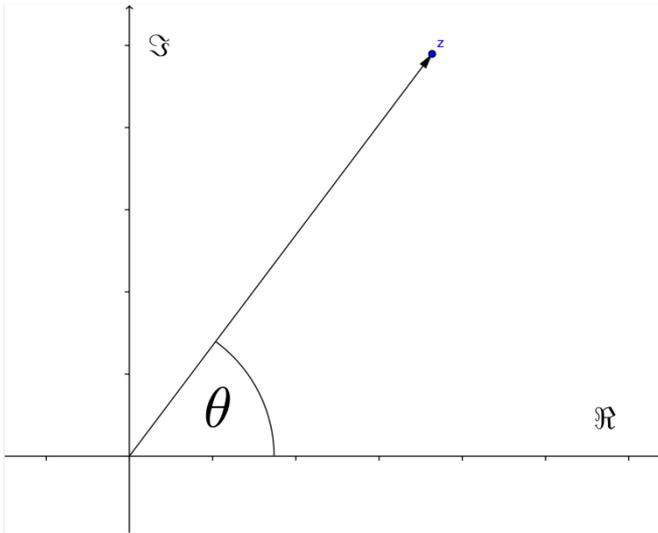
$$z_j = \left( \frac{1-n}{2} + j \bmod n \right) + i \left( \frac{1-n}{2} + \left\lceil \frac{j}{n} \right\rceil \right)$$

for  $j=0,1,\dots,n$ .

For our purposes, we chose  $h$  to be one-hundredth and generated a  $3 \times 3$  grid for each computation, which gave us an error on the order of  $1/100^8$ . The precision of our calculations could easily be improved, but test calculations showed that our error was trivial. The Mathematica code for this algorithm is found in the last section and is labeled *Code (1)*.

### **Akatsuka's Relationship and the Continuous Argument**

Since complex numbers can be visualized as vectors in the plane, we can define the angle they make with the horizontal axis as the complex argument. In the figure, the argument of the complex number  $z$  is  $\theta$ . However, the complex argument is not continuous; that is, as a complex valued function wraps completely around the origin, the value of its argument increases first from 0 to  $\pi$ , and then jumps to  $-\pi$  and decreases back to 0. For example, the argument one quarter of the way around the origin is the same as the argument one and a quarter of the way around the origin. We can fix this irregularity by requiring that the argument continue to increase as it winds around the origin, and rename this modification the continuous complex argument. Concretely, the continuous complex argument one quarter of the way around the



origin is  $\pi/2$ , while the continuous complex argument one and one quarter of the way around is  $5\pi/2$ .

In his 2012 paper *Conditional Estimates for the Error Terms Related to the Distribution of Zeros of  $\zeta'$*  [Aka], the Japanese mathematician Hirotaka Akatsuka showed that, assuming the Riemann Hypothesis, one has for the first derivative,

$$N_0(T) = N_1(T) + \frac{T \log 2}{2\pi} - \frac{1}{2\pi} \arg \left( -\frac{2^{\frac{1}{2}+iT} \zeta'}{\log 2 \zeta} \left( \frac{1}{2} + iT \right) \right) + O(1)$$

where the *arg* term represents the continuous complex argument. The most significant difference between Akatsuka's relation and Spira's is the *arg* term, and, in fact, this term provides a method by which one might disprove the Spira conjecture. Specifically, by increasing the value of T, it is plausible that the *arg* term above will become larger and larger in absolute value. The regions in which the *arg* term becomes large enough are good candidates to count the number of zeros of Zeta versus the number of zeros of the derivative of Zeta and produce a counterexample to Spira's relationship.



*Function* by E.C. Titchmarsh [Tit] says that there is a number between 2 and 3 such that the derivative of Zeta in the half plane to the right of that number is zero free. Therefore, to avoid these issues, promising values of  $T$  can be found by calculating the argument first up a vertical line starting at 3, and, upon reaching the prescribed height of  $T$ , turning ninety degrees to the left toward the critical strip. The figure to the left illustrates this strategy. The points with green rays emanating to the left represent zeros of either Zeta or its derivative. In his paper, Akatsuka defines the continuous complex argument in the region excluding these zeros and all points directly to their left, so we avoid these points and the green rays.

Mathematica comes with a built in function,  $\text{Arg}[z]$ , which computes the argument of a complex number  $z$ . However,  $\text{Arg}$  is not continuous, so for our purposes we needed to write code that would incorporate continuity. From the Mathematica online forums, we found code [Cel] that augmented Mathematica's  $\text{Arg}$  function to be continuous. The code defined a function called *phase* that took, as input, a list of complex numbers and gives, as output, the continuous complex argument along the path drawn by the inputted list.

To create the lists that *phase* would act on, we split up our path into a vertical and horizontal part and used the derivative code detailed in the last section. The path that is chosen should avoid all troublesome zeros, and at a height  $T$ , such zeros occur with a frequency of the logarithm of  $T$ . Thus, our function *vertval* that creates our vertical points moves in step sizes of the inverse of the floor of the logarithm of  $T$ . For the horizontal section, the function *hrzval* moves from the top value generated by *vertval* to the critical line in the same step size going vertically. We then concatenate these two lists and feed the resulting list to *phase*. The whole process is facilitated by the function *akat*, which inputs a height  $T$  and outputs the value of the *arg* term in Akatsuka's equation. The Mathematica code for this whole procedure is found in the last section and is labeled *Code (2)*.

## Counting Zeros

Once the previous programs find regions in which the *arg* term grows sufficiently large, we need to be able to count the zeros of the Riemann Zeta function and its first derivative. Counting the zeros of Zeta itself was pleasingly simple; by utilizing the built-in Mathematica function `ZetaZero`, which outputs the  $k^{\text{th}}$  zero of Zeta for any inputted integer  $k$ , it was a straightforward application of a while loop to construct a list that contained all of the zeros with imaginary parts between 0 and  $T$ . The raw Mathematica code is contained in the last section and is labeled *Code (3)*.

Counting the zeros of the first derivative of Zeta was a much more complicated process. The algorithm that was utilized relies on the Argument Principle from complex analysis: for a meromorphic function like the derivative of Zeta, the change in the argument around any closed loop is equal to the difference between the number of zeros minus the number of poles inside the closed loop, multiplied by  $2\pi$ . In order to compute any zeros with imaginary parts between 0 and  $T$ , we created a grid of points and computed the argument of the derivative of Zeta around loops throughout the grid. Any loops that had a change in argument larger than  $2\pi$  contained at least one zero, so this procedure returned a lower bound on the number of zeros. At the present moment, the final details of the algorithm are being worked out. Specifically, the program will take any loops that exhibit a significant change in argument, and grid out the interior and rerun the whole process, thereby more accurately finding the locations of zeros.

## Future Work

Presently, the project is in the debugging phase. That is, most of our programs are fully constructed, but we keep finding small errors that must be worked through. Once such discrepancies are handled, we plan on utilizing our algorithm to try and find

regions in which Spira's conjecture may be disproven. Mathematica contains the first  $10^7$  zeros of the Riemann Zeta function, but if we cannot find any hopeful regions for those first zeros, we may need to employ more advanced techniques to continue the search.

## Appendix

### The Mathematica Code

This section contains the raw code that is utilized in all the algorithms detailed above. The lines that are in Courier are actual lines of code, while the lines that follow inside the (\*\*) are comments explaining each block of code.

#### *Code (1)*

```
Unprotect[Power];  
Power[0, 0] = 1;  
Protect[Power];
```

(\*This block tells Mathematica to define the indeterminate  $0^0=1$ \*)

```
grid[n_?OddQ] := grid[n] =  
  Table[((1 - n)/2 + Mod[i, n]) + I ((1 -  
    n)/2 + IntegerPart[i/n]), {i, 0, n^2 - 1}]
```

(\*This function produces a  $n \times n$  grid centered at the origin. The first point is on the bottom left and proceeds along the rows. It only evaluates for odd input, so that the grid is centered\*)

```
h = 1/100;  
pts = grid[3];  
vand = Table[(pts[[i]]^j)/j!, {i, 1,  
  Length[pts]}, {j, 0, Length[pts] - 1}];  
mvand = Table[(pts[[i]]^j)/j!, {i, 1,
```

```
Length[pts]], {j, 0, Length[pts] - 1}]
//MatrixForm;
```

(\*h represents the spacing between points generated in grid[n]. pts is grid[3] to start as a simple example. Both h and the number of elements in pts can be increased to increase accuracy. vand generates the matrix of Taylor series coefficients based on the list pts.\*)

```
richardson[f_, z_, k_?IntegerQ /; 0 <= k <=
Length[pts]] :=
Module[{v, sol, answ},
  v = Table[f[z + pts[[i]] h], {i, 1,
Length[pts]}}];
  sol = Dot[Inverse[vand], v];
  answ = N[h^(-k) Part[sol, k + 1]]]
```

(\*This function computes the kth derivative of an expression (f) at a value (z) accurate to  $(1/h)^{(\text{Length}[\text{pts}]-(k+1))}$ . v is the vector defined above. sol multiplies the inverse of vand and v. answ outputs the desired derivative.\*)

```
z1richardson[z_] :=
  richardson[Zeta, z, 1]
```

(\*specialization of richardson to the derivative of Zeta\*)

## Code (2)

```
phase[l : {_?NumericQ ..}] := Module[{args =  
Arg[l]},  
  args + Prepend[2 Pi Accumulate@-  
IntegerPart@Differences[args/Pi], 0]]
```

(\*Definition of the function 'phase' which takes in a list of function values and computes the continuous complex argument. The code was found, unaltered, from <http://mathematica.stackexchange.com/questions/5782/implementing-continuous-phase-arg-function> from the contributor celtschk on May 21, 2012\*)

```
fakat[x_, y_] := fakat[x, y] =  
N[2^(x + I y) z1richardson[x + I y]/(Log[2]  
Zeta[x + I y])]
```

(\*This is Akatsuka's function inside the arg defined here simply so we don't have to keep typing it over and over.\*)

```
vertval[1] = Table[fakat[3, i], {i, 0, 1}];  
vertval[t_] := vertval[t] =  
  Join[vertval[t - 1],  
    Table[fakat[3, i], {i, t - 1, t,  
      (Ceiling[Log[t])^(-1)}]]]
```

(\*Produces a list of values of fakat up the vertical line with real part equal to 3 up to a height t where the step size between (t-1) and t is (Ceiling[Log[t])^(-1).\*)

```

vertphase[t_ /; t >= 1] := If[IntegerQ[t],
  phase[vertval[t]],
  phase[Join[vertval[IntegerPart[t]],
    Table[fakat[3, i], {i, IntegerPart[t], t,
      (Ceiling[Log[t])^(-1)}]]]]]

```

(\*Applies phase to the list created by vertval. Incorporates whether or not the input is an integer so we don't get any repeated values.\*)

```

hrzval[t_ /; t > 1, s_] :=
  Append[Table[fakat[i, t], {i, 3, 1/2, -((10^s)
Ceiling[Abs[Log[t]]])^(-1)}],
  fakat[1/2, t]]

```

(\*Produces a list of values of fakat across the horizontal line segment at height t from real part 3 to the critical line in steps of  $((10^s)\text{Ceiling}[\text{Log}[t]]^{-1})$ \*)

```

hrzphase[t_, s_] := phase[hrzval[t, s]]

```

(\*Applies phase to hrzval, where hrzval takes steps of  $((10^s)\text{Ceiling}[\text{Log}[t]]^{-1})$ . We can vary the second input of hrzval to decrease the step sizes until phase converges.\*)

```

akat[1] = 1.207558446820752;
akat[t_ /; t > 1] := Module[{a, b, x, c, d},
  a = Last[vertphase[t]];
  x = Prepend[
    hrzval[t, 0], Exp[I a]];
  b = phase[x];
  c = b + N[2 Pi IntegerPart[a/(2 Pi)]];

```

```
d = Last[c]]
```

(\*Picks out the last element a of vertphase, an angle, then creates a list x starting with  $e^{(i a)}$  followed by hrzval. Then b applies phase to x. Next, c recovers the information lost from  $e^{(i a)}$ . And finally d picks out the last element of c.\*)

### ***Code (3)***

```
kthzero[k_] := kthzero[k] = N[Im[ZetaZero[k]]]
```

(\*Produces the imaginary part of the t<sup>th</sup> zero of Zeta\*)

```
countzero[t_] := Module[{a, b},  
  a = Table[kthzero[i], {i, 1, 1}];  
  b = 2;  
  While[Last[a] <= t, a = Append[a, kthzero[b]];  
  b++];  
  Length[a] - 1]
```

(\*Counts the number of nontrivial zeros of Zeta with imaginary parts less than t. We initialize the table a by putting only the first zero in. Then, the while loop keeps adding zeros to a until the last element is bigger than t. Finally, the output is the length of the list minus one, to account for the first zero we already placed.\*)

## References

[Aka] Akatsuka, Hirotaka, 2012: Conditional Estimates for Error Terms Related to the Distribution of Zeros of  $\zeta'(s)$ . *J. of Number Theory*, **10**, pp. 2242-2257

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# **Can't Get it Out of My Head: The Effects of Rumination and Social Support on Collegiate Athletes When Losing a Game**

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## **Abstract**

*Research suggests that rumination, or over-thinking a situation, is linked to a negative impact on an athlete's performance on the field (Scott, 2004). The research team<sup>1</sup> hypothesized that rumination could be a psychological consequence of losing that may be present in collegiate athletes. To investigate the role of rumination in athletes' perceptions of their performance, we recruited 137 male and female Division I and club collegiate athletes from the University of California Santa Barbara, and administered a questionnaire designed to assess how much they ruminate after a loss and what type of support (or negative feedback) they receive from their teammates and coaches. Because past research suggests gender differences in rumination (Jose, 2007), we predicted that female athletes would ruminate to a greater degree after a loss. We also hypothesized that women would perceive less support from coaches and teammates after losing. Our final prediction was that positive support from coaches and teammates would result in athletes ruminating less. Results demonstrated that athletes ruminated, with gender differences appearing in only Division I athletes with women ruminating more than men. Additionally, Division I female athletes perceived less coaching support compared to males. Furthermore, strong teammate support was correlated with less rumination. The conclusions suggest new directions for research and enhanced approaches to coaching.*

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<sup>1</sup> Dr. Steve Smith, Jorge Ballesteros, and Marina Landheer

## **Introduction**

Rumination refers to repetitive thinking about a situation or circumstance that has occurred in the past (Scott, 2004). Rumination affects people of all ages, occasionally in unhealthy ways, linking to depression and inhibiting people from reaching their goals (Davis, Mezulis, Simonson, 2011). Rumination and the effects it might have on how athletes cope after losing a game have not been widely studied. The concept of rumination, however, has been a topic in psychology for years, particularly in the realm of social relationships.

In our study, we investigated the effects of rumination on athletes' coping strategies after an upsetting event, specifically, coping strategies after losing a game. We defined coping as how athletes dealt with or handled a loss. We tried to investigate if there were gender differences in how collegiate athletes ruminate because past research has found that women dwell on intimate relationships, personal appearance, and personal achievement more than men, leading to women ruminate more than men (Jose, 2007). We also examined how coaching and teammate support affects rumination and, in turn, affects coping. Coaching support refers to the extent to which a coach encourages his or her athletes to do better after losing a game. Teammate support refers to how teammates' words of encouragement or lack thereof affect an athlete's ruminating thoughts after a loss.

We predicted that rumination would have a negative effect on how athletes deal with losing a game. In addition, we predicted that women would ruminate more than men. Finally, we hypothesized that positive support from teammates and coaches would correlate with athletes reporting lower rumination scores. It is important to investigate how rumination may be affecting collegiate athletes coping strategies after losing because it may negatively impact their athletic performance or their personal life. One of our main goals was to provide guidance to sport psychologists and coaches when they implement healthy coping strategies when assisting athletes after losing a game.

## Literature Review

“Rumination refers to a form of repetitive thinking that is characterized by unintentional preoccupation with one’s problems and internal states as an end in itself rather than as a means to effective action” (Jostmann, Karremans, Finkeneaur, 2011, 506). Rumination, in other words, is thinking about a situation that has occurred in the past and, depending on the extent someone ruminates, how it affects other aspects of a person’s life. Rumination has not been studied in the context of how athletes cope with losing; rather, it has primarily been studied in psychology as an aspect that negatively influences relationships and its possible correlation with depression. We identified only a few sport psychology articles that investigated rumination and a possible connection with negative performance.

Scott, Stiles, Raines, Koth (2004) conducted a study to investigate how rumination affected collegiate tennis players and their athletic performance. Their results indicated that the more athletes tended to ruminate, the more their athletic performance declined (Scott et al, 2004). Even though this article did not strictly apply to our research question due to its lack of focus on teammate and coaching support, it did provide a questionnaire to modify and implement in our study. Maxwell’s 2004 study investigated whether there was a correlation between aggression and rumination in Chinese athletes. He found that provocation and rumination were significant predictors of subsequent aggression (Maxwell, 2004).

Although rumination might impede any athlete’s performance, gender differences are important to consider. Jose’s (2007) research on adolescents demonstrated that females reported higher levels of stress and depression which correlated to females ruminating to a larger extent than males. Because women ruminated more in the Jose study, we were interested to observe if those results would be similar in the sports world because female athletes are under similar or even more pressure when playing

sports. Based on Jose's findings, we hypothesize that women will ruminate to a greater extent than men when dealing with a loss because sport participation can lead to stress and depression through losing a match, trying to impress the crowd, or having a bad performance.

Coping refers to how one deals with an internal or external problem. Gaudreau, Nicholls, & Levy (2010) identified some of the different types of coping mechanisms athletes can exhibit after losing a game. Task-oriented coping is a strategy that helps in dealing directly with a stressful situation. Gaudreau et al. found that task-oriented coping maximized achievement in athletes because facing the problem head on is, for the most part, the best way to deal with a loss. Disengagement-oriented coping refers to a person's withdrawal from the process of actively striving toward the realization of desirable outcomes, including strategies such as behavioral disengagement, denial, and the use of alcohol or drugs (Gaudreau, Nicholls, and Levy, 2010). These findings may have important implications for coaches dealing with athletes who have suffered a dramatic game loss, because coaches can guide their players toward useful mechanisms to employ in dealing with losing a game.

Coaches are a vital part of organized sports; they are the ones who give direction and might be able to help a team pick up its spirits when they are down. Athlete and coach relationships vary: some may be extremely personal while others are strictly professional. How coaches act toward their players can have a huge impact on how athletes perform because it has been demonstrated that supportive coaching behavior is positively related to positive self-talk and negative coaching behavior is related to negative self-talk in athletes (Zourbanos, Hatzigeorgiadis, Tsiakaras Chroni, & Theodorakis, 2010). Positive reinforcement from a coach can help athletes bounce back from their failures, which may be an underlying factor in how much an athlete ruminates. Coaching support has also been linked to an athlete's competence and success. "Athletes who perceived their coaches to exhibit high frequencies of information following

desirable performances and high frequencies of encouragement and support following undesirable performances scored higher on measures of perceived competence, perceived success” (Amorse & Horne 2000, 356).

Therefore, coaching support can be vital to how athletes rebound from a loss. Even though there has not been much research on the role coaching support may play in rumination, coaching overall has a vast impact on an athlete’s ability to recover from bad performances. Although coaches are a key aspect of sports and how athletes perform, they are not the only source of support for many athletes.

Teammates can also provide positive or negative support after a bad performance or loss. Although in this area as well there has been little research done, the research team hypothesized that positive teammate support will help athletes ruminate less after losing. Holt et al. conducted a study with young female soccer players and found that when new athletes on the team received positive support from their teammates they felt less pressured and more welcomed, which lead them to perform better (Holt, Black, Mandingo, Fox, & Tammiminen, 2008). Holt et al.’s findings that positive support from teammates leads to greater performance may be an underlying aspect of rumination because athletes might tend to ruminate less when their teammates are welcoming and supportive, but future research needs to be conducted to support that hypothesis.

Even though Holt et al.’s study focused on women, it seems reasonable to assume that male athletes would perform similarly under conditions of welcoming and positive support from teammates. “Athletes also need to build a positive friendship with their teammates because more adaptive peer relationships with teammates leads to more enjoyment, and self-determined motivation as well as lower levels of anxiety and self-presentational concerns” (French, Hurley, Smith, Walker, 2006, 363). French et al.’s study indicates that the type of friendship that

athletes have with their teammates may affect the type of support they receive. If athletes have thriving friendships with their teammates, than there is less pressure between teammates to perform well, which in turn, may lead to less ruminative thoughts. Furthermore, strong friendships with teammates might lead to positive support when losses occur. However, if they do not have positive relationships, than they may feel under greater pressure to do well that can lead to greater rumination after losing a game.

## Method

### *Participants*

All athletes from the university were asked to take the study, and 137 collegiate athletes, identified through random sampling, completed the questionnaire. Of these 137 athletes, 88 were male (64% of the sample) and 49 were female. Of the Division I athletes, 30 were female, (21.8%) and 57 were male (41.6%); of the club athletes 19 were females (13.8%) and 31 were males (22.6%). The sports that these athletes engaged in were softball, rugby, volleyball, baseball, track, swim, surfing, lacrosse, and bowling. The majority of athletes in our sample were European Americans.

### *Measures and Design*

The questionnaire for this study used many different measurement tools, including the Scott McIntosh Inventory on Rumination (Scott, et al., 2004). This inventory has three components: a ***distraction component*** measuring how much ruminating thoughts prevent athletes from doing what they want; an ***affective component*** assessing the extent to which an individual is made to feel emotionally liable by ruminative thoughts, and a ***motivation component*** indicating how much ruminative thoughts push the person to reach their goals (Scott, Stiles, Rain, Cotch, 2004). We took the questions from the inventory and geared them toward how athletes might feel after losing a game. Examples of the questions ranged from “I feel more motivated than before to win” to “I often think about it so much that I get distracted from

what I'm doing." There were ten questions, roughly three for each component. The rating was on a seven-point Likert scale from strongly disagree to strongly agree, with neutral being in the middle. We decided to use this scale because it had been used in prior sport psychology studies and it was helpful in assessing rumination.

In addition, one of our questions required us to assess and measure the level of *coaching support*. The athletes received a revision of the Coaching Feedback questionnaire that consisted of eight feedback responses designed to measure the type of support they receive from a coach (Amorsore & Horn, 2000). For the purpose of our study, we used the five out of the eight feedback responses which focused on bad performances by an athlete. These were: mistake-contingent encouragement, ignoring mistakes, corrective instruction, punishment, and corrective instruction combined with punishment. Each feedback scenario represents a type of response a coach can give to an athlete after he or she has made a mistake while competing. For example, on the questionnaire, the athletes were asked how often their coach did or did not correct a mistake they made during a loss. The lower the overall score, the less support the athlete perceived.

For our study, we also needed to design a questionnaire that would help identify a possible correlation between team support and rumination after losing. The questionnaire consisted of statements such as "Teammates blame me for the loss" or "Teammates lend positive support after losing." The questions regarding teammates consisted of five statements that were rated on a likert scale ranging from one to seven, where one was never and seven is always.

The study used a correlational design to measure if the variables had a linear relationship. The independent variables were coaching support and teammate support, while the dependent variable was rumination levels.

## *Procedure*

For our study we used e-mail to contact UCSB collegiate athletes from Division I and sport club levels. The email message had a link to SurveyMonkey.com and there was also a printable version for the athletes to fill out in person. After receiving consent from the coaches, we attended some team meetings to explain the study to the athletes. Most of the athletes took five to ten minutes to complete the questionnaire in person. The athletes were instructed to place the completed survey in an envelope when finished. There was no incentive to respond to our study because NCAA rules prohibit receiving any type of prize or cash reward. Distribution of surveys began in the Fall of 2012 and we accepted questionnaires until February of 2013. The research team sent out email reminders to the athletes to respond to the survey between fall and the last due date.

## **Analysis & Results**

The data for our analysis were based on the 137 responses that we received. We measured rumination, teammate support and coaching support as experienced by each athlete. We used preliminary correlations to analyze the data and examine the degree of linear association between the study variables. We ran an ANOVA, which compares means between two variables, to see if there is a statistical difference between the means.

We hypothesized that women would ruminate more than men. We divided the data between Division I and club athletes. As **Table 1** indicates, we found that gender had no significant effect on rumination patterns in club athletes  $F(1,49)=.197$   $p=.659$ . However, amongst Division I athletes, there was a significant difference in gender on rumination scores  $F(1,85)=7.23$ ,  $p<.01$ . Women Division I athletes reported ( $M=31.97$ ,  $SD= 7.22$ ) ruminating at a higher rate compared to males ( $M=28.25$ ,  $SD=5.4$ ).

**Table 1 Ruminations Scores by Gender & Elite Status**

Status	Male Mean (SD)	Female Mean (SD)	Df	F	Sig.
Club Athletes	29.9 (6.78)	29.1 (5.48)	1	.197	.659
			48		
			49		
Division I Athletes	28.2 (5.4)	31.9 (7.72)	1	7.226	.009
			85		
			86		

To answer our second question, we used an ANOVA in an attempt to show if there was a gender difference in how athletes perceive coaching and teammate support. We hypothesized that female athletes would have lower perceptions of coaching and teammate support. As indicated in **Tables 2 and 3**, we found that there was no statistical significance between male and female club athletes' perceptions of support from either coaches or teammates  $F(1,47)=.062$   $p=.804$ . We also discovered that there was no statistical difference between male and female Division I athletes' perceptions of teammate support  $F(1,86)=-9.13$   $p=.342$ . We did, however, find statistical differences in gender perceptions of coaching support  $f(1,85)=-5.58$   $p<.05$ . Women Division I athletes perceived less support than male Division I athletes.

**Table 2 Club Athletes Coaching and Teammate Perceptions**

Club Athletes	Male Mean (SD)	Women Mean (SD)	DF	F	Sig.
Coaching Support Perception	13.9 (5.33)	13.5 (4.45)	1	.062	.804
			47		
			48		
Teammate Support Perception	13.8 (4.91)	13.2 (4.88)	1	.193	.663
			47		
			48		

**Table 3 Division I Athletes Coaching and Teammate Perceptions**

Division I athletes	Men Mean (SD)	Women Mean (SD)	Mean Square	F	Sig.
Coach Support Perception	17.05 (5.85)	20.17 (5.88)	1	-5.558	.021
			85		
			86		
Teammate Support Perception	14.16 (4.54)	13.16 (4.91)	1	-.913	.342
			86		
			87		

The research team examined the relationship between rumination and teammate and coaching support. We hypothesized that greater coaching and teammate support would result in less rumination by the athletes. These relationships are explored in **Tables 4 and 5**. The first correlation was with club athletes and there was no statistical significance for either teammate support and rumination patterns,  $r(49)=.277$ ,  $p=.051$  for coaching support and rumination patterns  $r(49)=.025$ ,  $p=.864$ . The second set of correlations with Division I athletes demonstrated that there was no correlation between coaching support and rumination patterns  $r(85)=.204$ ,  $p=.058$ . There was a moderately strong negative correlation between teammate support and rumination  $r(85)= -.315$ ,  $p<.01$ . That correlation signifies that the more positive support athletes receive, the less they will ruminate or vice-versa the more negative support they receive the more they will ruminate.

**Table 4 Club Athletes Coaching & Teammate Support Correlation**

	Rumination	Coach Support	Teammate Support
Pearson Correlation	1	.025	.277
Rumination Sig. (2-tailed)		.864	.051
N	51	50	50

**Table 5 Division I Athletes Coaching & Teammate Support Correlation**

		Rumination	Coach Support	Teammate Support
Rumination	Pearson Correlation	1	.204	-.315**
	Sig. (2-tailed)		.058	.003
	N	87	87	87

**Discussion**

The results demonstrate that when compared to men, women Division I athletes showed higher rumination scores. This may be attributed to the fact that women’s collegiate sports has only existed at current levels since the passage of Title IX opened up opportunities for women. Young female athletes are possibly more affected by loss compared to males due to higher stress levels, leading to higher rumination patterns. The correlation that teammate support affects rumination patterns is vital because in the future if coaches do not want their athletes to ruminate then they need to promote team chemistry and encourage teammates to support one another.

This was a preliminary study and therefore had several limitations. First, it was a non-experimental design, which made it difficult to discern the effect of one variable on another. For a clearer picture of the causal processes, we would need to run a controlled experiment. In addition, time constraints left the issue of coping unexplored. Given more time, I would have drawn coping questions from past literature and used these results to analyze rumination patterns in the athletes. Finally, the questions that were used to assess coaching and teammate support had

validity issues because even though they were taken from past questionnaires, the research team changed them to fit our study. The questions were changed to deal specifically with support that athletes may encounter when ruminating after losing a game. The variation in the survey questions helped in our analysis because we asked about support in a specific circumstance.

## **Future Research**

Future research might examine the relationships of particular sports to the extent of rumination and whether different people in particular positions in a given sport may ruminate more or less. For example, does a quarterback ruminate more than a wide receiver or running back? Historically the quarterback has the most pressure on the field because he is the leader of the team and some players might not be able to perform well under those circumstances. Other research might investigate professional athletes to see if, after playing for a number of years, losing might not affect them as much as when they were new to the game. We might also ask whether some professional athletes who have been performing at their sport for years ruminate more when they missed that game winning opportunity. Age and ethnicity might also matter. It would be instructive to discover whether there are rumination differences between ethnicities because it is possible that minorities might feel more pressure to compete well. Minority athletes might be under greater pressure because sports may be a way out of poverty, which may possibly lead to more rumination. Finally, it would be beneficial to analyze rumination patterns between different age groups to show at what age rumination is present.

In conclusion, the study provides insight on gender differences in rumination patterns in collegiate athletes as well as possible variables that can help relieve rumination. The study findings may provide assistance to coaches and sport psychologists. Coaches with knowledge from the study can promote team camaraderie and positive support after losing to

lessen rumination. Coaches may tailor their strategies to have a friendly and welcoming locker room where teammates can build friendships and bonds. For sport psychologists, the findings may help them filter their clinical work with athletes that may engage in rumination.

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# **Strategies of Persistence: African American Women in Higher Education**

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## **Abstract**

*Research on the relationship between African Americans and higher education has primarily focused on identifying the attitudes and behaviors that inhibit academic persistence. Current research identifies the factors that negatively influence African American students through statistical evaluations of their performance. However, the research has not adequately incorporated the voices of African Americans and has not focused on the experiences of African American women. Although it is important to understand the factors that inhibit performance, research must also identify the attitudes and behaviors that enhance persistence for marginalized groups. This project explores the perspectives African American women have in regards to their education, their definitions of academic success, and their feelings about the university as it relates to their experience as undergraduates. Giving voice to a group that is often neglected in research, it explores how African American women in higher education balance the demanding aspects of their lives, such as work, home*

*life, and personal relationships, with their academics, and how they employ what I term “strategies of persistence”. This project aims to ascertain the ways in which African American women cope with factors that have been shown to negatively influence their performance in academia, such as lack of academic preparation, racism, sexism, and class inequality, and to highlight the way that institutions of higher education may better advocate for African American women students.*

## Introduction

**"We know who we are only when we know who we are not and often only when we know whom we are against"**

**- Samuel P. Huntington**

African American students at predominately white institutions of higher learning often refer to themselves in terms of "the only." The term "the only" and the stress and isolation that results from one's own minority status, is a reoccurring theme in the findings of my research. Finding themselves singled out both as "the example" and as "the exception" due to their position as "the only," African American students develop their self-concept and identity at their universities under exclusionary circumstances. In response to their experiences of alienation, many African American students develop an identity fortified by independence and resilience (Andrews, 2009). For it is through the daily reminders of who they are not that many African American students develop who they are, who they should be, and who they want to be.

In his book, *Clash of the Civilizations, 1996*, Political Scientist Samuel P. Huntington argues that the most violent wars have occurred as a result of a clash of civilizations, or essentially a clash of cultures. Huntington's theory presumes that as the world becomes increasingly interconnected, the misunderstanding between cultures will cause the greatest conflict. Though Huntington is not a scholar of education, I use his theory to conceptualize the positionality of African American women at predominately white institutions of higher learning. Utilizing the *Clash of Civilizations* framework, I investigate the mental, emotional, social, and physical conflict that African American women face when placed in an environment in which they appear not to belong, such as a predominately white institution. Huntington's argument is based on the notion that difference is a prerequisite to conflict. As a result of this difference, African American women find themselves simultaneously tokenized and

ignored by their peers, professors, and the institution itself (Solórzao et. al, 2000; Smith et. al, 2011). This clash of culture is identifiable not only in extreme instances of racism, but also through simple daily microaggressions and experiences that serve to isolate African American students from their surroundings.

Education has been a right that African Americans have had to struggle to acquire from the days of slavery. The tumultuous relationship between African Americans and access to equitable education has laid the foundation for the way African Americans have come to view their opportunity to receive a valuable education in this country (Ogbu, 1990). African Americans have experienced the American education system as one of refusal and denial: refusal to educate them while they were slaves, the denial of their intellect on the basis of eugenics, the legal refusal to grant them equitable education through school segregation, and now, a systematic denial of resources to fund the education of the poor who are disproportionately people of color. Thus African Americans are not only wary about placing trust in governmental policies surrounding education, they are also unconvinced that the system will ever change (Ogbu, 1990).

The structure, administration, and personnel of institutions of higher learning play a large part in fostering the tone of these communities. It is from higher-level personnel that student academic and social expectations are set, often times working within the apparatus of a particular school mission. The work of career personnel at the university is to create a welcoming and safe environment for all students, regardless of race, gender, sexuality, religion, or any other aspect of their identity. Establishing a safe and welcoming environment is no simple task; nevertheless it is important to maintaining and hopefully increasing persistence rates of those who enroll at institutions of higher learning.

In order to increase persistence, it is important to understand the ways in which African Americans and other marginalized groups experience institutions of higher learning.

Understanding the challenges that marginalized students face is valuable because our country cannot afford to have entire populations of people discouraged by or unable to succeed in an institution because of racism, sexism, or classism. If we hope to achieve equity in our education and world, we must address aspects of our education system that disregard the needs of those from marginalized communities of color or cultures.

Many scholars who have attempted to understand what is required to succeed in education have not fully considered the effect that the intersectional identities of students have on their educational outcomes (Kuh et. al, 2006). Whether from sociological or psychological perspectives, very few theorists consider the ways in which such theories are complicated by the minority status of students, except for referring to the plight of the first generation student. Some social scientists, whose work uses critical race theory, consider the effects that marginalization has on one's perception of education and make room to incorporate minority voices, but often this work does not wholly address what can be done by administrations to meet the needs of students. Focusing specifically on marginalized groups allows researchers to gain a clearer understanding of what students do for themselves in order to persist at their institutions of higher learning. The next step in the research is to identify the tangible steps that university administrations can take in order to better attend to the needs of their minority students. Specific attention must be paid to the admission and retention of underrepresented students, showcasing successful practices of many individuals rather than focusing on the shortcomings of the few.

My research contributes to the effort to understand the needs of African American women students by introducing the voices of this historically underrepresented group into the conversation about their retention rates and experiences. There are three parts to my research question:

- How do African American women view their education and the university?

- How do academic preparation, classism, racism, and sexism influence the perspective of African American women students at a predominately white university?
- How do African American women's perspectives about their education influence the way they balance academics with work, home life, social and political activism, and their relationships?

Scholars of higher education who focus on the experience of minorities at institutions of higher learning have affirmed that the perspective that a person of color holds about American institutions can influence the way they interact with that institution (Ogbu, 1990). Thus, we can infer that if a student not only distrusts American education, but also their specific predominately white institution, that these feelings may affect the way they perform academically, as well as how they connect to the university and their peers. Research has shown that students of color face a wealth of challenges that they must overcome with respect to their home lives, their finances, and their relationships (Allen 1992; Steele, 1997; Sellers, 1998; Kuh et al., 2006). Though much is known about the challenges that students of color face, not much is understood about how such students grapple with their responsibilities, their goals, their feelings in regard to themselves, or how their perspective about their place in higher education affects the way they distribute their time and energy to make their time at predominately white institutions enjoyable and successful.

## **Literature Review**

Minority voices have not always been present in the research done about them in the academy. Most data has been collected quantitatively and the knowledge about the experiences of minorities has not made clear the challenges of the students themselves. Beyond parsing the history of African American's access to higher education, many researchers have employed large-scale projects to investigate the academic performance and

persistence of African American students, and the factors that inhibit success. Though the use of quantitative measures is useful when trying to understand the status of a particular group's educational outcomes, it cannot be used to effectively convey the lived experiences of African Americans in higher education. This is because the life experience of individuals cannot be relegated to numbers and graphs. Thus, by solely utilizing quantitative methods to investigate African American students, the minority voices are not only absent, they are erased.

The statistical information regarding retention rates and grade point averages that often tell a tale of an "underperforming" minority experience is not wholly reflective of the reality of an underrepresented minority student in higher education. It undermines, by means of exclusion, the daily challenges that minorities face and the sacrifices these students make in order to make their education enjoyable and possible.

Although the struggles of African Americans in the university have not been thoroughly addressed in the academic literature, the efforts of African Americans to gain access to higher education have been well documented. The African American's journey to higher education first began with Historical Black Colleges and Universities (HBCU). Although the first HBCUs were established in 1837, a majority of HBCUs were established after the American Civil War in order to teach newly freed slaves how to read and write (Sedlacek 1999). After the Civil War, the long lasting effects of racism and prejudice barred many African Americans from established universities in both the North and South. Though some African Americans were able to attend schools in the North, these opportunities were rare and not without their own challenges. In the post-bellum South HBCUs were especially necessary, as the possibility for an African American to receive an education at a white institution was nonexistent. Thus HBCUs were created as necessary means for African Americans to educate themselves and each other in the face of exclusion at other institutions of higher learning.

Most college-educated African Americans received their degrees from these historically Black colleges and universities (HBCU) until the 1960's due to segregation (Sedlacek, 1999). As a result of the historic ruling in *Brown vs. Board of Education*, coupled with the success of the Civil Rights Movement, doors to predominately white universities began to open for minorities. The political and cultural changes taking place in the United States allowed African Americans to gain access and admission to the institutions from which they had been formerly barred. Throughout the 1960's and 1970's large numbers of African Americans attended predominately white institutions (Allen, 1992).

Despite the promise of desegregation, African Americans quickly realized that being admitted into institutions of higher learning didn't mean that the racist structures of institutions and administrations had changed. Many African Americans did not feel as if their universities addressed their specific needs. Without support for minorities built into the infrastructure of predominately white institutions, the enrollment and retention rates of African Americans declined in the 1980's and remain poor today (Allen, 1992). Fortunately, the below average retention rate for African Americans at predominately white institutions led to a body of research regarding the predictors and inhibitors of persistence for African Americans and other marginalized groups at predominately white universities.

Researchers have shown that success at the university is dependent on the socioeconomic status, academic preparation, and the living and learning environment of the student as well as the relationship between faculty and students (Sedlacek 1999, 1). Other scholars have argued that in addition to these factors, the occupational aspirations of students, coupled with social involvement on one's campus, are strong predictors of persistence (Allen, 1992, 28). Moreover, support from friends and family, belief in one's self, and feeling cared about by the institution have all been identified as indicators of the likelihood that a student will persist at a predominately white university (Kuh, Kinzie, Buckley,

Bridges, Hayek, 2006, 6-8). For a typical African American student at a predominately white university, it may be unlikely that he or she would be able to have all or even some of indicators of success. In fact, the research indicates that their experiences at the university and in their personal lives may leave them seemingly unable to succeed. Coupled with the indicators of success are also institutional and societal systems that can negatively affect the academic performance of African American students, resulting in lower grade point averages, academic disqualification, or a decision to withdraw from the university.

Racism has major implications for the African American student attending a predominately white university as explored in numerous studies (Solórzano et al, 2000; Steele and Aronson, 1992). For many African American students, college is the first time they are in the racial minority. Thus, college becomes the first time they are confronted with how they might be viewed in the eyes of people of other races. Moreover, if enrolled in classes in sociology and ethnic studies, African American students might also experience their first instance of learning about their own African American history in more depth than in secondary school. This new information on systemic oppression, environmental racism, and various other forms of racial disenfranchisement can be beneficial to raising the consciousness of African American students but it can also be detrimental to their desire to accept the values of the institution.

In their compilation of education research, Kuh et al. (2006) found that experiencing a connection to the university through participation in school activities and relationships with staff and faculty and one's peers is essential. Some studies indicate that faculty and staff play a role in fostering or undermining African American students' connection to the university. When asked about faculty, students stated that some professors were unwilling to explicitly name racism as one of the causes of the disenfranchisement of minorities on their campus (Solórzano et al, 2000). This can be frustrating to African American students because they believed that a one sided view of issues was being

shown, and they assumed that the faculty did not understand their concerns. This disconnect in the classroom results in a chasm between African American students and their professors, negatively impacting the ability of African Americans to connect with faculty. How would a student who feels invalidated by their faculty make a connection with them or the university that employs them?

The racism that is present in our society inevitably finds its way into the university. Whether it is through holding stereotypical ideas and openly expressing them in “gangster and stripper parties,” where partygoers assume what they believe to be a persona of “blackness,” or having to assert themselves as scholars in the face of being repeatedly asked if they are students at the schools they attend, Black students often experience a host of both subtle and blatantly racist situations that may work to challenge their self concept and sense of belonging at their university. In 2008 African American students at the University of California, Santa Barbara rallied and conducted a silent march in response to the type of party mentioned above with duck tape over their mouths and signs that read: “I am not a gangster” and “I am not a stripper.” A similar instance of racism occurred recently at UC Irvine in May 2013 when a fraternity wore blackface during a video promotion for a party. Unfortunately, the racism embedded in these acts often under of the guise of it’s just “good fun,” serves to ostracize and “other” African American students. In addition to race themed parties, the “othering” of African American students can be done by those who challenge the intellect of African American students by attributing their admission into college to Affirmative Action (Solórzano et al, 2000).

In 1995, Claude Steele and Joshua Aronson investigated the underperformance of African American students in higher education. They were interested in the effect that stereotypes can have on a person’s performance. Steele and Aronson found that the belief that one will perpetuate a negative stereotype about a group with which one identifies adds pressure on that person and, in turn,

may lead them to fulfill that negative stereotype inadvertently. The researchers found that African Americans performed below their intellectual capacities when they believed that their failure could lead to the perpetuation of dominant stereotypes about the intellectual inferiority of African Americans (Steele & Aronson, 1995, 797-810). Steele and Aronson termed this phenomenon “Stereotype Threat.” Stereotype threat can be used to explain the disparities between the projected academic success of African Americans and their actual performance in higher education.

Many African American students feel the burden of representing their entire race when they are in predominately white spaces. This burden works as a pressure that others do not have to feel and for some students may hinder their ability to do as well academically as they are capable of doing. Research on the experiences of African American women in relation to their male counterparts in higher education remains focused on differences in behavior. For example, Walter Allen in his study on the student outcomes of African Americans at both predominately white and historically Black universities found that African American women were more likely to speak up for themselves at predominately white institutions. This contradicted the behavior of women at historically Black colleges. Allen reasoned that Black women at Black colleges “suppressed their assertiveness in order to cultivate relationships with men” (Allen, 1992, 30). Nevertheless, the outspoken nature of Black women students did not go unpunished at predominately white universities. Though Black women were successful in gaining academically on their campuses, they suffered by way of social isolation from their peers (Allen 1992). The findings of both Steele & Aronson, coupled with Allen, work together to create a framework in which the experiences of African American women can be understood. Special interest, however, may need to be paid to the double consciousness that some African American women create for themselves in order to exist as women of color in both Black community spaces on campus and well as in their white, male-dominated spaces.

The racism and sexism that students experience on campus is not always manifested as overt acts of discrimination. Being stereotyped, talked down to, or ignored can be acts that are interpreted by students of color or other marginalized groups as prejudicial judgments based solely on the color of their skin or their gender. These subtle insults that people of color experience have been named microaggressions. Microaggressions can be directed towards any member of an underrepresented group; however, a racial microaggression has been defined as “subtle insults (verbal, nonverbal, and/or visual) directed toward people of color, often automatically or unconsciously” (Solórzano et al, 2000). Daniel Solórzano and his colleagues investigated how racial microaggressions influence African American students and the racial climate of colleges. They found that in the face of prejudice, African American students retreat to “safe spaces,” or culturally controlled environments, where they believed they were safe from racial judgments.

Safe spaces have been erected at UC Santa Barbara in the form of culturally based clubs, the Multicultural Center, and the ethnic studies departments, all of which derive directly from the desires of African American and other underrepresented students and their allies to have places that were “theirs” on a predominately white campus. Understanding microaggressions and stereotype threat as obstacles in the African American student’s path to graduation and academic excellence at a university is just as pertinent as knowing what factors are predictive of success. As outlined in the work of Kuh et al, in 2006, there are many known factors that are predicative of success or failure for students at universities. However, I argue that simply knowing the factors that contribute to student success is not enough. Researchers must also look at how students persist even without access to the social capital, familial, and living factors that are predicative of success

One known way that minorities employ to persist at universities is to form and embrace a strong sense of racial pride. Some students may become involved in social justice issues, join

clubs such as the Black Student Union, or simply embrace their identity as a Black college student. It is important, however, to note that not all people of color want to bring attention to their race or gender. Some research has found that African American girls may not acknowledge themselves based upon their racial or gender identity. Signithia Fordham's ethnographic study of African American girls at a predominately white, urban high school sought to identify, "Why, how, and at what cost African American adolescents achieve school success?" (Fordham,1993). Fordham identified varied ways that African American girls operated in the unfamiliar environment of this predominately white school (most of the Black students were bused in from surrounding areas in order to diversify the learning environment). Fordham found that some girls that behaved in such a way as to "pass" in their environment (1993). "Passing," as Fordham defined it, is assuming characteristics that leave an individual genderless and raceless, and therefore translates as taking on the characteristics of white manhood. Fordham reasons that for some, femininity was a detriment to their ability to be taken seriously by their peers.

In addition to the girls who were intent on passing in their environment, there were other girls who chose the path of silence. In an effort to combat stereotypical images of the "loud Black girl," girls who chose silence used their existence as a means to resist the dominant ideologies about who society expected them to be. For these girls silence was a tool for success. The girls who embrace passing and silence share a common desire to be taken seriously. They understood that their Blackness coupled with their womanhood might hinder their academic pursuits; they believed that the only way to gain and maintain the respect of their peers was to present themselves in a manner that would never call their intellect into question.

In stark contrast to the silent and passing girls there were, what Fordham labeled "the loud Black girls." For example, in contrast to the silent girls and passing girls who were typically those who excelled academically, "the loud Black girls" were underachievers; Fordham argued that the more visible a Black girl

was, the more likely she was to have disparities between her grades and standardized tests. Fordham found that “loud Black girls” obtained higher marks on state administered tests than they received in the courses they took at their school. Fordham reasoned that the lack of congruence between grades and performance on state tests could be attributed to the effort these students invested in being visible on their campus as “loud Black girls.”

The nuanced nature of African American girls’ self-presentation in school must be understood in the historical framework of Black woman’s experience in America. The way in which Black girls operate in predominately white, male-dominated spaces is inextricably linked to the traditional roles that Black women played during slavery and Jim Crow. Controlling images of the “Strong Black Woman,” work in conjunction with mammy figures to impose a stereotypical paradox onto the bodies of Black girls/women (Collins 1990). The ‘strong’ Black woman is a feminized masculine identity that has been fortified by African American women by way of their resilience during the overt racism of the past and the strained racial climate of today (Collins 1990). Historically, Black women have been expected to perform all the same duties as their male counterparts while still maintaining their femininity by birthing and caring for their own children while raising the children of white families. In accordance with the image of the strong Black woman, African American girls are expected to embody the strength of men, thus they are not treated as fragile women, yet they are still required to embrace their “natural” role as women (Fordham, 1993).

Sixteen years after the Fordham study, Dorinda Andrews focused her research on high achieving Black students at a predominately white high school (Andrews, 2009). Andrews was interested in how Black students construct conceptions of their own achievement. She found through her interviews with the students that they contextualized their achievements in terms of their blackness. In other words, the students incorporated racial

pride into their understanding of their own achievement. Many of them expressed a desire to do well in school, simply because they understood that dominant society underestimates the intellectual capabilities of African American students. They firmly believed that success was not something reserved for white students. The students thought that anyone could be successful if they worked hard enough. Though they understood it would be hard for them because of their minority status, they also knew that their dedication to school would make them successful, regardless of the color of their skin.

Andrews' work can be compared to John Ogbu's 1990 theory of the involuntary minority. Ogbu argued that involuntary minorities, such as African Americans and Indians who became citizens of this country by force, greet the institutions of this country with hostility. Thus governmental institutions such as education have been deemed "white" and it is accepted by some within these communities of color that adopting the behaviors that are conducive to school success, such as speaking standard English, is the antithesis of their own culture, in this case "Black" culture (Ogbu, 1990). The fear of "selling out" or being called "white washed" can damage the academic careers of many students of color, and may alter the ways in which they perceive their education. Though an African American woman may still achieve great success in higher education, chances are she will still have to grapple with losing her authenticity in her community of color. This is not only a distraction and a source of frustration for African American women in college but also for those at any level of their education.

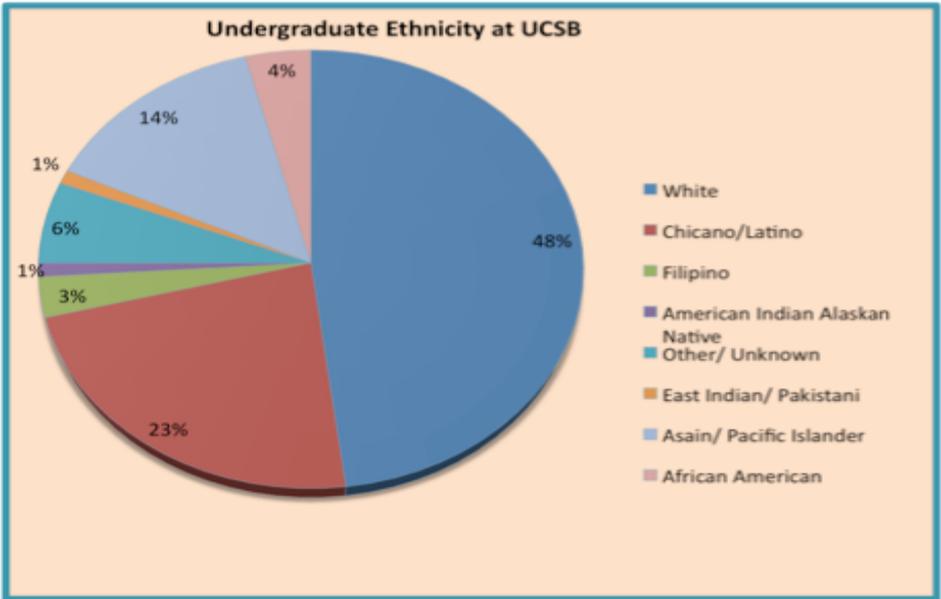
My goal as a researcher is to add to the current conversation regarding the success of African Americans in higher education. My focus in this study is to examine "how" underrepresented people, specifically African American women, understand themselves and their place at the university. I want to know how much of their motivation and self-definition is a result of the environment at their university. Although studies have been done on high achieving African American students, they have

primarily focused on high school students who attend predominately white institutions. The voices of marginalized students in higher education are surprisingly missing from the literature.

## Methods

### *Context*

The students interviewed for this study were enrolled at the University of California, Santa Barbara. The data below illustrate the overall racial composition and persistence rates at the university and allow for some understanding of the cultural climate of the university at which this research took place.



**Figure 1: Ethnic Distribution of Undergraduates (UCSB)**

From **Figure 1**, we can see the racial composition of UCSB. While there are large populations of both Asian and Chicano/Latino students comparable to the white student population, only four percent of the school’s 20,000 students

identify as African American. Though the number of students of color has increased over the last decade, white students still make up the largest proportion of the campus student population.

As evidenced in **Table 1**, a review of the enrollment records from the 2006 Fall Cohort shows that of the 2,385 African Americans who were admitted, only 114, or 4% of admitted African American applicants enrolled at UCSB. By 2012, only 67% of the 114 African American students who began their education in the Fall of 2006 graduated. Put simply, within 6 years, UCSB graduated only 76 African American students.

**Table 1: Six-Year Graduation Rates by Ethnicity at UCSB**

	African American	Native American	Asian American	Hispanic	Total Minority	White	Total Undergraduates
<b>Fall 2006 Cohort</b>	114	39	636	875	1,664	2,128	4,096
<b>6<sup>th</sup> Year Graduate Rate</b>	67%	72%	75%	71%	72%	82%	80%
<b>Number of Students</b>	76	28	395	621	1,198	1,745	1,908

## *Sample*

African American women comprise the majority of the African American community at UC Santa Barbara; the ratio of African American women to men is 2:1 (UCSB Campus Profile, 2012). This is consistent with national averages that indicate that African American women are attending college, graduating, and receiving graduate degrees at rates higher than their male counterparts.

The participants for this study were gathered by purposive sampling. Researchers use purposive sampling to ensure that a specific demographic is chosen for what it can offer to diversify data samples. Thus, all participants in my study are African American women in their third or fourth year of enrollment at the UC Santa Barbara and are 19-21 years old. I selected this group because of the familiarity they have with their collegiate community. Additionally, it has been found that if an individual persists to their third or fourth year of college they are highly likely to graduate from that particular institution (Kuh et al, 2009). The grade point average (GPA) of the participants was noted for purposes of coding the research data, but it did not determine whether a student participated. Unlike other studies, I am not defining success through GPA or test measurements.

While GPA is an important indicator of successful education practices such as academic preparation, good study habits, and engagement with the material, it does not leave room for a holistic definition of success outside of academic performance. For African American women, and other minorities, a more holistic model of the measurement of success needs to be implemented. Minority students cannot simply be measured by grades alone; grades and test scores cannot grasp the totality of the experience that encompasses the social, professional, and co-curricular activities that may contribute to their growth as individuals but inhibit their academic performance. Furthermore, their focus on social and co-curricular activities may be a strategy

of persistence, a way to connect to the university. Thus, I seek to look at the whole individual, their involvement on and off campus, their GPA, and their perspective to understand what makes these women feel successful.

### ***Procedures***

This study focuses on those who have been successful at the university because that is one way to understand what the institution, faculty, staff, and students are doing correctly to enhance the experience of undergraduates on their campus. Success for the purposes of this study is defined as persisting to one's third or fourth year of study. However, as a part of each interview, participants were asked to define success for themselves. "Strategies of Persistence," as defined by this study, are the study habits that participants' exhibit, their involvement in co-curricular activities, and their motivation to do so that have aided or motivated their persistence.

Data was collected in two forms: during a one hour-long interview session or through a focus group consisting of 6-8 women. Both interview protocols were comprised of open-ended questions regarding the experience of African American women on the campus and the ways in which they approach their education. Questions included: "What motivates you?" "How has this university changed or challenged you?" "Have you experienced racism or sexism at the university, and if so, how did that experience influence your ideas about the university, yourself, or your future?" These questions seek to understand whether the women make connections between the things that happened to them and their academic performance and self-esteem. Through gathering data about sources of motivation of people from underrepresented groups one can see what contributes to a desire to continue in a place in which they may feel uncomfortable. Furthermore, by understanding individuals' feelings in regard to their surroundings at a university, it is easier to decipher which behaviors or activities allow them to flourish as students.

Data on my sample of eight participants were analyzed through grounded theory. Significant results may be difficult to ascertain due to the small sample size. However, the data provides a means through which to consider some important elements in African American women's assessment of their education. .

## **Results**

My research data indicated that the following factors affect performance: academic preparation, connection to the university, and career aspirations. This is consistent with the findings and observations of many scholars of higher education. However, in the case of my African American participants, there wasn't a strong feeling of connection with the university. Many of them had a hard time asserting that they felt connected to the university at all. The lack of connection can be attributed in some part to the way in which African American students are made to feel as if they are outsiders. Moreover, some of my participants felt as though they themselves were not of value at their university. Participant Whitney Sampson stated: "I don't feel like the university cares about me. I don't feel protected by the university... and the people that care about me the university doesn't care about them either." Sampson's assertion can be understood in light of her observation of the ever dwindling funding for the Education Opportunity Program (EOP) at UCSB. For example, EOP plans an annual Summer Transition Enrichment Program (STEP) that caters to newly enrolled minorities, including racial minorities and low income students. In recent years STEP has gone from being a two-week program to just a week. STEP has remained funded due to the fundraising efforts of STEP alumni who believe in the mission of the annual event. For some students, this lack of institutional investment in the success of STEP directly translates into feelings that the university does not care about the needs of underrepresented students and does not value them. Considered this way, universities indicate who and what is valued on their campuses, and unfortunately, that is not often the faces or experiences of African American students.

Throughout my interviews I recognized myself in the comments of my participants. As a Black woman interviewing other Black women I was afforded a degree of access into the intimate thoughts that many of my participants may have not shared with me otherwise. Moreover, we were able to reflect on what we believe our roles as student leaders should be and what they actually are. Each of my participants believes that academics are the most important aspect of their time at the university. However, among them, there are conflicting and sometimes competing ideas about the role and duty of an African American woman at a predominately white institution. For some participants, African Americans are expected to be a role model for other African American undergraduates, showing them how to carry themselves in the university as well as guiding such students along the path of perseverance in order to achieve the outcomes that they desire from their college experience. For Whitney, participating in an organization allows her to be a role model for people who may not be familiar with strong images of Black women. Whitney says “I feel like everybody...wasn’t taught to persevere and [be] resilient and I feel like I can teach people through my organization.” This perceived social responsibility of teaching other students extends beyond the education of students who may say or hold racist ideologies about Black people or sexist beliefs about women at the university, or teaching others how to balance their schedules; it also includes following through with what needs to be done in one’s own community in order to assist in the growth of others. Due to the small number of Black students, the successes and shortcomings of each person reverberate throughout the community.

African American students have unique sets of pressures placed upon them with respect to their academic performance, including familial, financial, and social commitments. Many African American students are the first in their family to attend a four-year university. They often come from families that may be struggling financially and the guilt they may feel about being away from the family serves to further isolate them from the university and their peers. For Candice Thompson, being a good example for

her younger family members brought her both pressure and pride. Candice stated: “I have a whole family that is like depending on me, I feel like I have them riding on my back too... so it’s like the decisions I make are not only for myself.” This sense of responsibility may inhibit students of color from thinking individualistically; rather, such students frequently think about what will be best for their families, even though that may not be what is best for them in the future. This added pressure makes the idea of leaving school, even if being there is uncomfortable, nearly impossible. When asked, each participant in the study asserted that leaving school was never an option. Though they may cry, curse, and complain, getting a college degree is an objective they have set out to achieve and they are determined not to fail.

Though being bombarded with statistical information that shows the hurdles that African Americans face, some of these students use this data as a motivational factor. For Jazmine Andrews, staying in college is a tough decision that she is willing to make because she does not want to be reduced to a statistic of another African American student that couldn’t make it in the university. Jazmine states “It’s a struggle staying here so I make sure I’m not a statistic...that would be my biggest disappointment...”

The fear of being a statistic is genuine. The data about the economic, educational, and social shortcomings of African Americans can serve not only as motivation to succeed and defy the stereotypes about African Americans; it also can lead to frustration. At a predominately white institution, many African American women struggle with being a positive representative of their communities. Whitney states: “I didn’t know what it meant to represent a whole culture until I got here,... to teach somebody something and at the same time bottle up my emotions, so I can be able to be an example to someone else and teach them something about me.” Whitney’s powerful quote illustrates not only the burden of being a teacher to others, but also the personal implications of not being able to express her emotions for fear of

misrepresenting herself and her community through the perpetuation of stereotypes.

Campus involvement, one element of success, was emotionally and socially complicated for the study participants. Many of my participants believed that participating in more activities is what allows them to have a competitive resume. However, for others, community involvement was more than simply belonging to or even leading organizations. Community involvement served as a real escape from the stresses of home life, and provided an outlet for frustrations. In her interview, when asked why she chose to be involved, Jessica Johnson stated: “I think for me I’m always trying to be involved so I can forget what’s going back home.” For Jessica, organization work was about providing herself with the ability to take herself out of her family situations. As mentioned in Kuh et.al, Tinto’s interactionist theory states that individuals must detach from the roots of the former community in order to adopt the beliefs of their new community. Jessica’s decision is a worthwhile strategy for persistence, one that allowed her to adapt to her new surroundings. It also served as an isolating and heart breaking decision that caused her to feel as though she was abandoning her family. While familial constraints are not limited to the African American community, it is a popular narrative amongst African Americans in college. Many African American students at UC Santa Barbara, like Jessica, struggle to negotiate their identity as low income students- who may be from an economically disadvantage neighborhood with their newly acquired privilege of resources and class benefits that a college experience provides.

These women’s definition of success is also reflective of what they want out of their lives and therefore, the amount of effort they are willing to put into the work that they do. When asked how to define success many participants defined it as achieving far reaching goals that were rooted in class mobility and an upgrade in social status: house, kids, ideal career, and financial stability. For other women being successful was the ability to give back to the family members that contributed so much to their lives.

Jazmine stated that success was “Living comfortably and being able to provide for the ones you love without having to hesitate.” I found that almost all of my participants’ definitions of success focused on long-term goals. Though there is nothing inherently wrong with success being guided by long-term goals, defining success in this way did not allow participants to feel content with their accomplishments thus far. When I received a long-term definition of success from a participant, I followed up by asking how they would define success as a student. In all but one case, my participants correlated success as a student with GPA. Therefore, the definitions that I received about student success and success in general were similar to the ways that success has been defined in past quantitative studies: GPA goals and the tangible economic benefits that students are supposed to expect to receive following graduating from a four-year university.

However, though not considered by all my participants as success, involvement in community and the ability and willingness to give back to other Black students was factored into definitions of success and even personal pride. In this way success as a student and success as a community member, which could be inextricably linked, have become separate aspects of one’s ability to balance academic pursuits and perceived responsibility to be of service to peers. These separate assessments of success allowed my participants’ self-concept to be partially separated from their performance academically. While this was comforting as a researcher and a peer because it showed that my participants were able to see the worth in the work that they have done for others, I still find that believing in one’s success in social activities may not be highly beneficial. Despite the good students believe they had done, they still prized their GPA as the best way to measure their success as a student.

GPA remains the most relevant means by which individuals understand their success as students. For Jazmine success as a student would be to “have a 3.5 and above.” Agreeing with Jazmine, Adrianna added: “I believe being successful in school is

being able to pour all of your energy into academics. You shouldn't have to put effort into building relationships with people, I think your social life is a part of your success in college but it shouldn't be work, school should be your only work." Thus, extracurricular activities, though they may help to enhance an individual's leadership abilities, community building, or administrative skills, are still not seen as fully a part of the definition of a student's success. For Rachel Been her GPA score is what stood in the way of her being able to call herself completely successful. Rachel revealed that "I've gone down in success, the past year just because like I haven't met my GPA goal as much as much as I wanted to but umm but when it comes to helping others I'm successful." Unfortunately, relying on GPA to define one's worth as a student often causes many students to devalue the work that they do. Out of my eight participants, only one thought of herself as successful. Interestingly enough, she was the only individual who did not define success or her self-concept by her GPA.

## **Conclusion**

The culture shock that minority students experience when they enter predominately white institutions can be disillusioning. Many students leave, unwilling or unable to deal with the pressure, the difference, or the people. However, the individuals who remain at universities, do so to not only prove something to themselves, their peers, or society, but to also to set positive examples for their families. Though this undoubtedly adds pressure, African American women's resilience at their universities works to build and better their communities. The initial "clash of civilizations" may cause and facilitate daily struggles; those who stay learn how to navigate the murky waters of multiculturalism, acceptance, and tolerance.

Though each woman in my study had a strategy of persistence unique to her own experience, they can be categorized in three ways. Strategies of Persistence as exhibited by my participants include, but are not limited to, "Keeping your Eyes on

the Prize,” “Recognizing your Worth,” and “Reaching Back.” Women who believed that they persisted by “Keeping their eyes on the prize” positioned school as their main priority. By focusing specifically on their studies such students feel validated by their belief that that they are fulfilling their responsibilities as students. I would project that, on the whole, students who keep their eyes on the prize may have better grades but may not have the work or extracurricular activity as students at a large public institution. In direct contrast to students who have kept their eyes on the prize, are students who motivate themselves through working with others. This strategy is extremely important in marginalized communities, as many students find comfort and meaning through organizations such as the Black Student Union. Moreover, students who employ the “reach back” mentality position themselves as role models and therefore must make sure that they are taking care of their own business. This strategy, when artfully mastered, is a delicate act of balance between scholastic endeavors and community building. Though not many of my participants wholly exhibited this, I believe that students who do not define themselves by grades or breadth of student involvement may be more satisfied with themselves. By relieving themselves of the pressure to be a role model or a model student, such students allow themselves to truly do the things that make them happy. The three aforementioned strategies are not exhaustive, however, they add to a conversation about what marginalized students do for themselves despite being minorities on campus.

The UCSB Black Student Union has been a magnificent example of what student voices and actions can do for change. On March 11, 2013, UC Santa Barbara’s Black Student Union (BSU) submitted a list of demands to the campus administration that focused specifically on issues of admission and retention. BSU’s eight demands included the hiring of Black psychologists, enhanced recruitment of Black students by the Office of Admissions, and the hiring of Black faculty outside of the Department of Black Studies. The campus responded favorably to the demands, releasing a half million dollars worth of funds to

implement outreach programs, hire endowed chairs, a fulltime career staff in the Office of Admissions, focus specifically on the recruitment of Black students, and the funding of Student Initiated Outreach Programs. The work that the UC Santa Barbara Black Student Union has done will change the lives of students by providing students safe spaces, and adding more diversity to the campus, Black students may feel more comfortable attending the university as well as seek help when they are facing challenges. Though the 2013 demands were a huge accomplishment on behalf of Black students, I still look forward to the day that the needs of Black students are met without the need for demands.

In order to implement changes that will help insure the success of students of color, the voices of minority students must be introduced into the conversation. This is the purpose of this study, and should be the goal of research in the future. Researchers have noted the following factors as indicative of student success: academic preparation, future aspirations, comfort at the university, and student involvement. Sexism, racism, and classism can be negative factors that may influence how connected students of color will feel to their campus, especially if it is predominately white. This study seeks to understand the specific approaches that African American women employ in order to persist at a university where they may not always feel comfortable. Student comfort at the university should be a priority for university administration. However, to achieve that, the institution needs to develop greater understanding of students of color. Understanding the choices that African American women make in order to succeed is an important addition to the conversations about admission and retention rates of underrepresented groups in higher education. Students of color are underrepresented in the University of California system, and higher education in general. Studies on what discourages success are necessary for reform in education, but understanding what works for students is equally important.

## **Future Research**

Future research needs to focus on more positive aspects and experiences of students of color. Research should delve into the strategies of persistence employed by other underrepresented communities as well as those used by white students. Recognition of the varied ways in which students interpret their college education in light of less than promising job prospects post graduation, should be a next step in scholarly research. Discrimination in higher education may not be changed overnight; however a solid commitment by the university to truly educate all people who attend on social issues is a promising way to generate change. The material gathered from this study hints at the thinking students of color can employ when first introduced to the unfamiliar situations that are prevalent in predominately white institutions.

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# Surface topography characterization of mesoporous TiO<sub>2</sub> thin films used as coating of bone anchored implants

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## Abstract

*Mesoporous films are of great interest as implant coating because they have been shown to improve bone-implant integration, also known as osseointegration, due to the implant's unique surface topography. Although there has been significant research on microtopography, there is little known about the nanotopography's influence on osseointegration. In this project, TiO<sub>2</sub> mesoporous films coated onto titanium implants and glass substrates were examined using atomic force microscopy (AFM) for imaging and surface topography analysis. TiO<sub>2</sub> films with varying pore sizes of 2.5-3.0 , 4.2, 6.0 , 6.5 and 7.2 nm were synthesized using the Evaporation-Induced Self-Assembly (EISA) method known to produce uniformly porous films. Additionally, spin-coating was used to prepare the films. Varying pore sizes were used to determine their respective effect thus establishing an optimal pore size for the coating of implants. A non-porous film was used as a control surface. Key parameters such as surface roughness ( $S_a$ ) and root mean square ( $S_q$ ) of the films were calculated for each pore size. From the surface topography values of the glass substrates, it was determined that the film with pore size of 6.5 nm had the roughest surface while the pores of size 2.5-3 nm exhibited the smoothest surface. When the roughest film was applied to a titanium implant disc, the film did enhance the surface roughness*

*on the microscale level while reducing it at the nanoscale level. The results obtained are believed to have a direct clinical relevance in improving the biocompatibility of implants and are very important in the development of novel nanostructured implant surfaces.*

## Introduction

Mesoporous films are of interest as implant coatings because they improve bone-implant integration, also known as osseointegration, due to the implant's unique surface topography. Although there has been significant research done on microtopography, there is little known about the nanotopography's influence on osseointegration. Some of the surface parameters that are of concern to researchers are the surface roughness ( $S_a$ ), root mean square roughness ( $S_q$ ), and the density of summits parameter ( $S_{DS}$ ) [1]. These parameters can be calculated using various techniques, and the values can provide insight into determining how nanotopography features effect osseointegration. The Atomic Force Microscopy (AFM) instrument shows promising results in characterizing the films because it provides clear images at the nanoscale while providing measured values via MATLAB. In the most basic terms, an AFM captures an image using a reflective cantilever which contacts a sample surface [2,3]. While there are multiple methods to obtain surface parameters of mesoporous films, this paper discusses only the results determined through an AFM. Our research, as reported in this paper, covers the significance and effects of using mesoporous films as coatings for bone-anchored implants. Through the surface parameters obtained from the AFM, we determined the effectiveness of a film's roughness in terms of osseointegration. To characterize the film, we (1) made the films (2) autoclaved the film, and (3) imaged the films using an AFM.

I begin by discussing the relevance of mesoporous films in implants as well as the imaging method of Atomic Force Microscopy. I then turn to how the mesoporous  $TiO_2$  films were prepared for imaging. In the results section, I discuss how we classify the images and the values obtained. Lastly, I present the significance of the results and future work needed.

## Imaging Process of Mesoporous Films

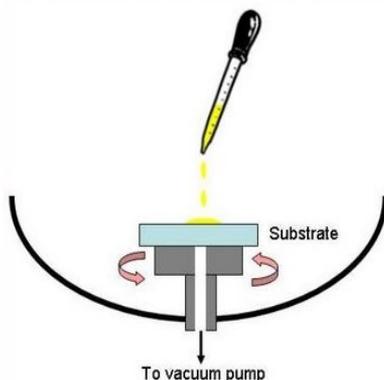
There are many methods to create films. The spin-coating method is one that is commonly used because it is simple and straight forward. The  $\text{TiO}_2$  used in the mesoporous films characterized is well known due to titanium dioxide's versatility and wide use in material science. In addition, most implants make use of titanium; thus, the chemical integrity of the overall system will be maintained [4].

In this section, I will discuss the spin-coating method, the Evaporation-Induced Self Assembly (EISA) method, and the Atomic Force Microscopy (AFM) imaging method, which were all used in this project.

### *Spin-Coating of Mesoporous $\text{TiO}_2$ films*

In the spin-coating process, a solution is deposited onto a substrate; once the solution is deposited, the substrate's rotational speed is accelerated to allow the solution to spread on the surface. The rate of rotation is usually in the thousands and denoted by rotations per minute (rpm). The speed of the substrate influences the thickness of the film; the higher the spin rate, the thinner the film. In addition, the substrate used for spin coating is based on the film's application. If the chemical properties are expected to be retained during the process, glass or silica is often used because they are inert.

**Figure 1**, below, is a basic schematic of the spin-coating method. The method is simple, and once the solution is added to the substrate, the spinning of the substrate creates the film. As the figure shows, the substrate is held in place by a vacuum pump that sucks the substrate in place while spinning. This method of spin-coating is widely used in electronics and thin film productions due to its simplicity and efficiency.



**Figure 1.** Schematic of spin coating process. [Google Sites]

### ***Evaporation-Induced Self-Assembly (EISA) Method***

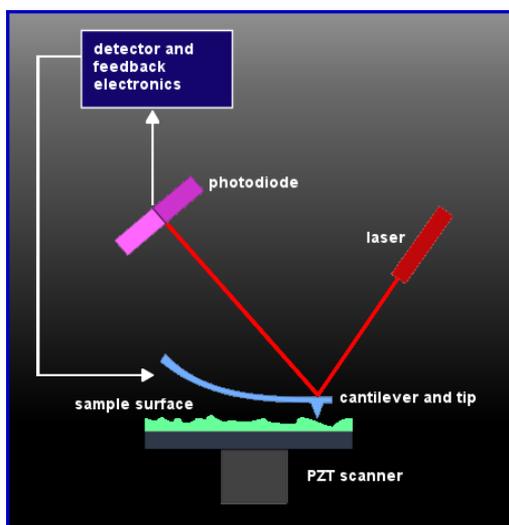
Mesoporous  $\text{TiO}_2$  films were produced using the EISA Method because the method results in uniform pore-size films. The films' pore size has been analyzed in previous studies and a narrow distribution of the sizes is observed using the EISA method [4,5]. Furthermore, if the polymer template is removed, the method produces thin films with the same chemistry; thus, a control film can be used.

The EISA Method takes advantage of thermodynamics and surface chemistry to produce a film. A solution consisting of water, ethanol, and a surfactant is used and spin coated onto a substrate [5]. Once the film has been deposited, it is set to dry. While the film is drying, the ethanol is evaporated; the evaporations cause a concentration gradient shift of the surfactant. The surfactant's overall concentration in the water increases as the ethanol is evaporated, and as the concentration increases it reaches a critical point. The critical point consists of a maximum amount of micelles, round vesicles made from aggregation of surfactants in solution.

Ultimately, the aggregated surfactant molecules provide the structure for the pores on the films. The films are then placed in an autoclave to finish evaporating any residual ethanol, which allows the film's final surface chemistry to be formed. This method has wide applicability since different solutions can be formed for different film objectives [5].

### ***Atomic Force Microscopy (AFM)***

The AFM allows imaging of non-conductive and conductive materials. It provides three-dimensional profiles at the nanoscale through interactive forces. A probe on the AFM contains a cantilever that makes contact with a surface through attractive or repulsive forces. **Figure 2**, below, depicts a basic schematic of the AFM and its components. The main components are a laser, photodiode, cantilever, tip and PZT scanner.



**Figure 2.** Schematic of AFM. [Oakland University 2013]

The mode in which the AFM operates determines the characteristics that can be obtained. Semi-contact or intermittent mode was used for imaging the mesoporous films. This mode allows the conservation of the sample because it does not apply a large amount of force. In intermittent mode, the AFM taps on the surface without contacting or damaging the film. This mode, however, does limit the amount of data obtained because there is a lack of quantitative theory [2].

AFM allows for a wide range of imaging scales starting from 100  $\mu\text{m}$  (micrometers) to the nanometer scale. The size of an imaging range obtained depends on the resolution; thus, it may vary with sample. To compare nanotopography features with microtopography features, images within both realms must be absorbed. The images are obtained at 10  $\mu\text{m}$ , 5  $\mu\text{m}$ , 1  $\mu\text{m}$ , and 0.5  $\mu\text{m}$ . Additionally, each film must be sampled multiple times for consistency. In our research, each film was sampled three times. A clear outline of the operational conditions and their respective specifications used for the AFM analysis are shown in **Table 1**.

**Table 1. Operation Specifications for AFM analysis**

<b>Operation</b>	<b>Specification</b>
Mode	Semi-contact (tapping)
Scan sizes	10, 5, 1 and 0.5 $\mu\text{m}$
Scan frequencies	1 and 0.5 Hz
Samples taken	3 per film

The scan frequency of the AFM image was alternated to determine how the speed of the cantilever and tip affected the image. In the discussion to follow, we will analyze the results from the two different frequencies.

### **Preliminary Measurement Results**

When characterizing the films, we used the images obtained for visual comparisons and quantitative values for each film. AFM is useful because it allows the sample's information to be exported as a MATLAB file, which allows for computational analysis. In addition, the AFM uses MATLAB code for its calculated values; thus, the characterization values are accurate.

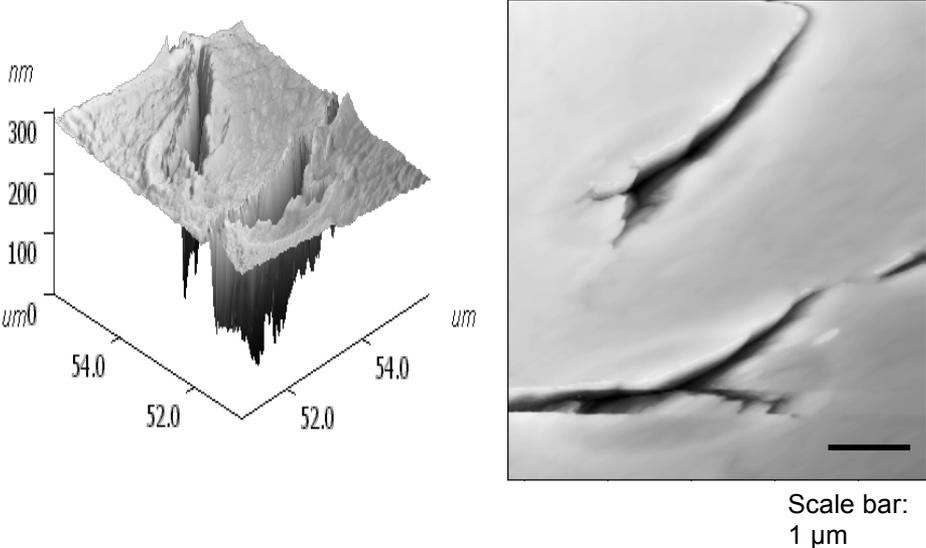
For this experiment, six different films were made for characterization. Five of the films had different polymer-templates resulting in various pore sizes; the sixth film was nonporous and was used as a control. The five mesoporous films along with their template are detailed in **Table 2**. Each template corresponded to a different averaged pore size calculated within the film.

**Table 2. The five films characterized and their respective template.**

<b>Sample film pore size</b>	<b>Template</b>
7.2 nm	PPG1
6.5 nm	PPG0.5
6.0 nm	P123
4.2 nm	CTAB
2.5-3.0 nm	Brij S10

The different pore sizes in the film created the variety in surface properties, which was clearly observed when imaging the films. **Figure 3** demonstrates the image seen when sampling the PPG0.5 film. The AFM allows 2D images to be converted to 3D images for analysis. This proved to be useful when observing the depth of the pores or, in the case of the PPG samples, cracks along the surface of the film.

Since the AFM takes the x, y, and z coordinates of the image, multiple calculations can be accomplished. The z-coordinate is vital for the calculations of roughness values for the films. However, when the AFM is reading the image, errors such as noise or surface angling might alter the z-value; therefore, a third order subtraction was applied to account for the disturbances.



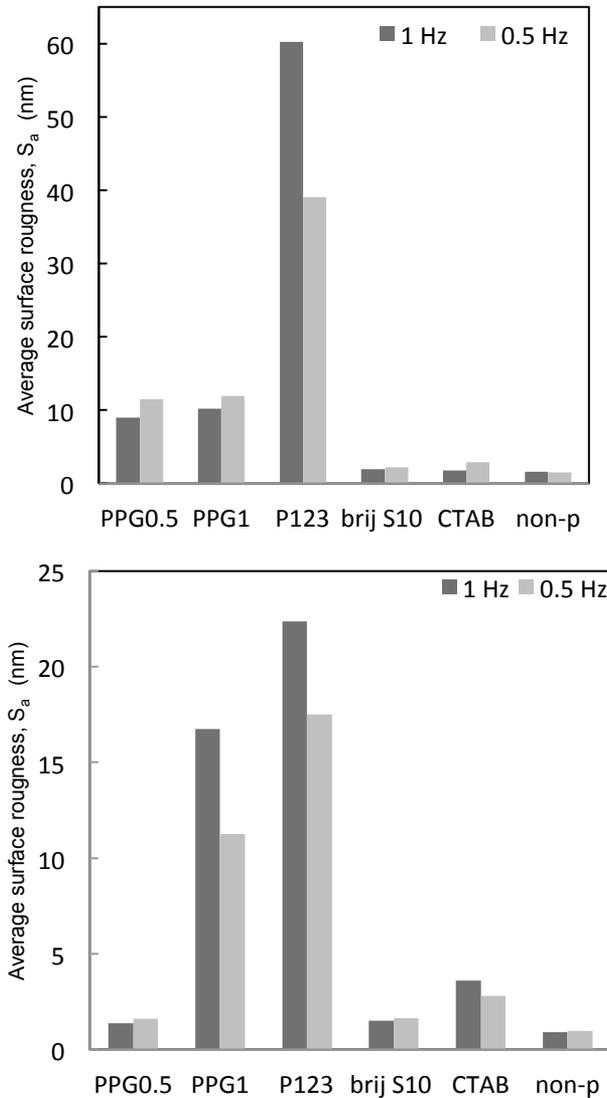
**Figure 3.** 3-D (left) and 2-D (right) image of PPG0.5 with a third order subtraction. The 3-D image is a segment from a 100 x 100 um scan. [Santizo 2013]

## *Surface Roughness (Sa) values*

The surface roughness is a useful parameter because it provides insight into the surface's topography. It gives you a value calculated over the whole sample; with each scan size huge discrepancies in values may be observed. The surface roughness is defined as the average value of the height in the sample. It measures the average "depth" of a sample area called the roughness. Due to its simplicity, it is used in film calculations as a comparison value.

According to Wennerberg et al., one can classify the roughness values into four categories: (1) smooth; (2) minimally rough; (3) moderately rough; and (4) rough. This study demonstrates that smooth ( $Sa < 0.5 \mu\text{m}$ ) and minimally rough ( $0.5\text{-}1 \mu\text{m}$ ) surfaces have little to no effect on an increase of osseointegration while moderately rough ( $1\text{-}2 \mu\text{m}$ ) and rough ( $Sa > 2 \mu\text{m}$ ) showed some response to an improved osseointegration [1].

In **Figure 4**, the films tested are shown at two different scan sizes and scan times. The scan time was altered to determine the effect of the tip movement over the sample area. The non-porous (non-p) shown is the control sample. It is a smooth film opposed to the porous films being observed. The difference in scan areas shows how the roughness is affected by the change in area sampled.



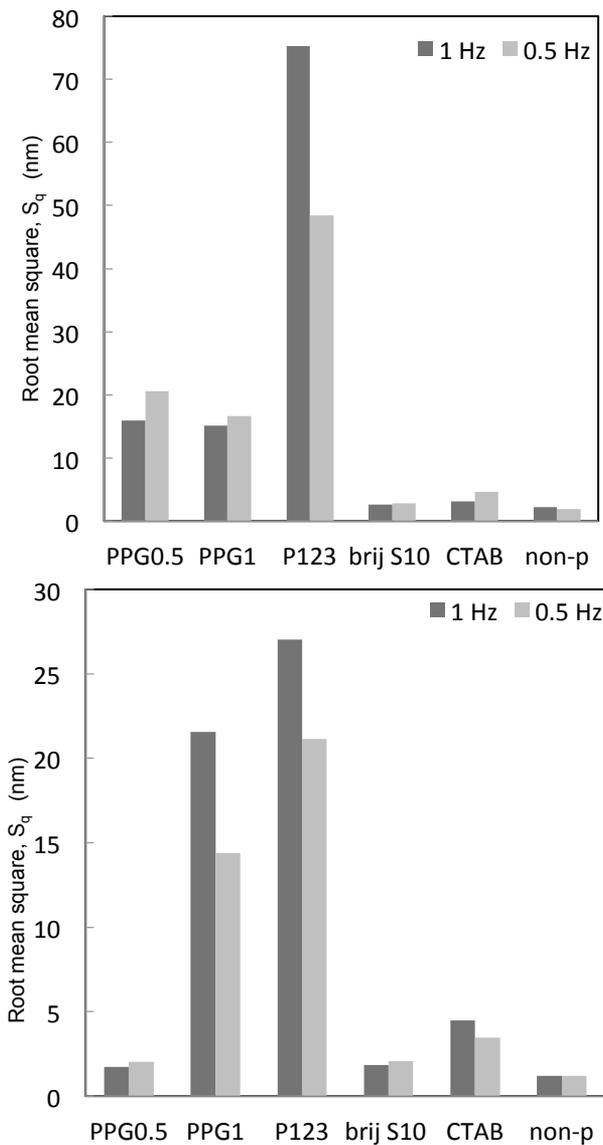
**Figure 4.** Surface Roughness ( $S_a$ ) of films on substrate at scan size of 10  $\mu\text{m}$  (top) and 500 nm (bottom) [Santizo 2013]

From the values obtained, it was determined that the P123 (6.5 nm pore size) template film is the roughest in both scan sizes with values averaging approximately 60 nm in the 10 um scan size. The smoothest sample as shown by the graphs is brijS10 (2.5-3nm pore size) with a roughness less than 3 nm in both scan areas.

### ***Root Mean Square Roughness (Sq) values***

The root mean square roughness, which is a height measurement, is a similar value to the surface roughness. However, the root mean square function squares the calculated depth before averaging it. Due to the squaring of the value, the root mean square is more sensitive to differences in heights from peaks and valleys in the sample suggesting that this value is more accurate since it is more sensitive to changes in the surface. Just like the surface roughness, the root mean square roughness is simple to calculate and can be commonly used for statistical purposes.

In the **Figure 5** below, we observe the root mean square of the films for two different scan times and scan sizes. From the images we can determine that the observed trends from the surface roughness are correct; P123 is the roughest film and brijS10 is the smoothest. The major difference in the results of the values obtained is the P123 film, which has a roughness of approximately 75 nm at scan size of 10 um for the root mean square.



**Figure 5.** Root mean square ( $S_q$ ) of films on substrate at scan size of 10  $\mu\text{m}$  (top) and 500 nm (bottom). [Santizo 2013]

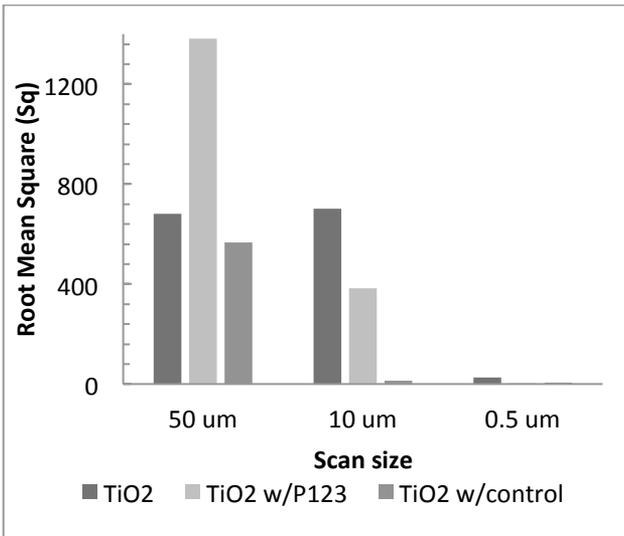
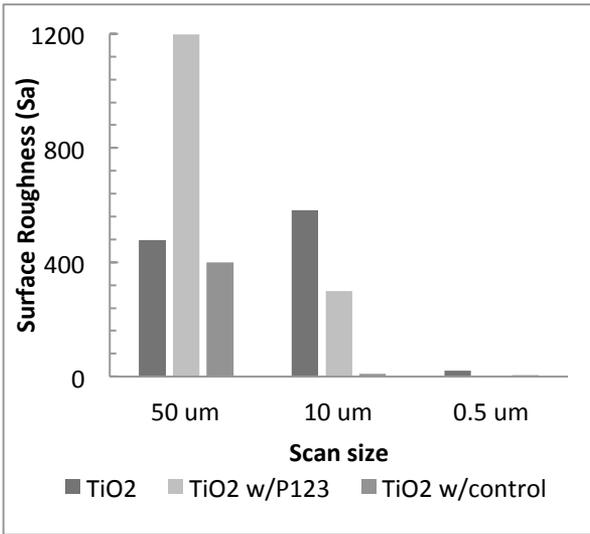
## *TiO<sub>2</sub> implant discs experimental values*

While the mesoporous film coated on a substrate provides insight into the roughness values, it is not a precise calculation of the roughness of actual coated implants. Thus, TiO<sub>2</sub> implant discs were used to observe the films' effects of coated implant discs. From the results of the mesoporous films on the substrate, we decided to coat TiO<sub>2</sub> implant discs with the roughest film and nonporous film to determine what effects the mesoporous film has on the actual implants. Doing this analysis allows a comparison between the values obtained for the films on the substrate and the values for the films on the implant disc.

The size of the implant was approximately 2 cm and the same spin coating process was used to make the film. The parameter values for the implant films were slightly different. Three scan areas (50, 10, and 0.5  $\mu\text{m}$ ) were chosen and one scan frequency (1 Hz) was used. **Figure 6** illustrates the results from images of the implant discs.

From **Figure 6**, we can conclude that at the microscale level (50  $\mu\text{m}$ ) the mesoporous film significantly increases the surface roughness; the actual value increases by a factor of approximately three. At the same scan area, the non-porous film slightly decreased the roughness of the implant. At all smaller scan areas tested, both the mesoporous and nonporous films drastically decrease the roughness indicating that coating the film does not improve the roughness at the nanoscale.

However, this result should be approached with caution because further analysis and extensive testing must be performed before concluding the nanoscale results.



**Figure 6.** Surface Roughness (top) and Root Mean Square (bottom) of TiO<sub>2</sub> implants uncoated and coated with mesoporous films. [Santizo 2013]

## Discussion

From the results presented above, an understanding of the influence of mesoporous films on the roughness of a surface was developed. The significance of the values calculated and their implication for films as coatings for bone-anchored implants will be discussed next. Both topics are crucial for furthering the research in the areas of materials science and implant medicine.

### *Significance of the values*

From the values obtained in **Figures 4 and 5**, we notice that the values obtained for the synthesized films are smaller than literature values reported by Wennerberg [1]. While there is a deviation from the Wennerberg's studies, it is unclear what scan areas are being reported, thus no clear comparison can be made. Additionally, a larger amount of samples and scan repetitions are needed to reach a definitive conclusion. The comparisons drawn in this paper only discuss the samples made for this analysis.

The results demonstrated that larger pore size does not imply a rougher surface. The P123, which has the third largest pore size, resulted in the highest values. This result implies that the surface chemistry may also have a role in the surface roughness; the polymers have different concentration stabilities and properties; thus, when forming the film, different thicknesses arise and cause different roughness values.

Furthermore, when comparing the values of the implant discs there are vast differences as the scan area is decreased. These values are not only dependent on the scan area but as mentioned above they are also dependent on the deposition of the film. The implant discs and substrates used for the analysis differed in area and shape, thus the films effect on the surface will differ. An understanding of the shape's influence in film thickness needs to be established to aid in concluding the influence of mesoporous films on bone-anchored implants.

## ***Implication of films for implants***

Since the film's influence on a surface is inconclusive, the effect of the film on implants is also uncertain. Nonetheless, it was observed that the microtopography is enhanced, as the literature states [4]. This shows that films will become beneficial when producing bone-anchored implants since these types of implants require good biocompatibility and osseointegration to be successful. Coating implants will decrease the body's rejection of the implant resulting in a decrease of implant incidents that might hinder the health of a patient.

Ultimately, a complete understanding of the type of roughness needed for a proper integration of an implant will have a tremendous impact on biomedical engineering; new implants will be developed that will satisfy the biological system requirements. This type of development will lead to safer, longer lasting and stronger implants that will aid in a patient's recovery.

## **Future Work**

To enhance the value of the research project, additional work is needed that increases the number of times each film is imaged, increases the use of implants for comparative analysis, and applies different operational conditions. These added study design features will enhance the data obtained for characterization of surface topography, which will aid in advancing implant technology. Precise measurements and characterization of the films are needed in fields of bioengineering, biochemical engineering, and biomedical sciences; thus, the work mentioned above will create standards to use when creating coated implants. Additionally, there are multiple modes that can be used for AFM imaging. Establishing the best mode and operational conditions will also help ensure that the data obtained is accurate. In

conclusion, the improvements stated will have a significant effect in the medical field and in the way implants are designed and used.

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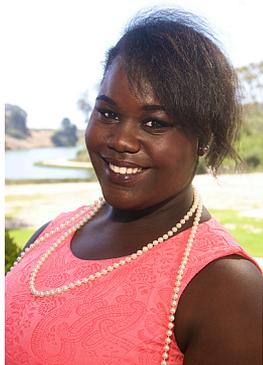
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**Nathan Lopez** was born and raised in the San Francisco Bay Area. For his freshman and sophomore years, he attended UC Santa Cruz before transferring to UC Santa Barbara. He graduated with a Bachelor of Science in Mathematics in the winter of 2014, and, in the fall, he plans to enroll in the PhD program in Mathematics at the University of Illinois at Chicago. After completing his doctorate, Nathan's goal is to become a professor. Direct correspondence

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**Nathaniel Vassar** transferred to the University of California, Santa Barbara from California State University, San Marcos. As a Geophysics major, he found a mentor in Dr. Chen Ji who invited him to take on the challenge of starting a new line of research in analyzing hydraulic fracturing data from industry. Working with Dr. Ji as a McNair Scholar, Nathaniel helped to determine the best way to use the project data given the

tools available at the university. This project is now established as a primary line of research in Dr. Ji's lab, with a focus on determining focal mechanisms and stress drop in microseismic events, as well as a more detailed waveform analysis. Immediately after graduation, Nathaniel will be taking part in a 4-week course in the Nevada desert then heading to Wyoming to participate in a field course with ExxonMobil. Nathaniel plans to continue working on his research, initially in industry and then in graduate school. Direct correspondence to: [nvassar@umail.ucsb.edu](mailto:nvassar@umail.ucsb.edu)



**Ronald E. McNair** was born on October 12, 1950, in Lake City, South Carolina. Son of an auto mechanic and a high school teacher, McNair attended the local high school, graduating as class valedictorian. He went on to earn a bachelor's degree, magna cum laude, in Physics, from North Carolina A & T University in 1971 where he was named a Ford Foundation Fellow and a Presidential Scholar. McNair met a goal that he had set in high school to complete his PhD within 10 years. Five years after graduating from college, he received his doctorate in Physics from M.I.T.

Nationally recognized for his work in laser physics and the recipient of numerous fellowships, honorary degrees, and commendations, Dr. McNair was also a sixth degree black belt in karate and an accomplished saxophonist. In 1978, while working at the Hughes Research Laboratory, he was selected for the NASA space program. He was the second African American to fly in space. On January 28, 1986, Dr. McNair, along with 6 other astronauts, died when the space shuttle Challenger crashed exploded and crashed into the ocean moments after lift-off.

After his untimely death, Congress provided funding to start the Ronald E. McNair Post-Baccalaureate Achievement Program. UCSB's McNair Scholars Program is dedicated to helping promising scholars follow Dr. Ronald E. McNair's path of scholarship and service.

The cover features a photo of the Goleta Pier at sunset. Captured by talented young photographer Noah Kai Dalton-Schneider, a high school senior when this image was taken, the Goleta Pier juts out into the Pacific, and sits adjacent to the UCSB campus. The 1,450 foot pier is a treasured landmark, both for the campus and the surrounding communities.



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