

McNair Scholars Research Journal

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TRiO

McNAIR SCHOLARS PROGRAM



UNIVERSITY
OF WYOMING

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The McNair Scholars Program

Background

The University of Wyoming McNair Scholars Program was established in September 1992 and is one of the only 160 programs in the nation. The University of Wyoming and the United States Department of Education jointly support the program named for an accomplished scholar of physics and an astronaut on the Challenger space shuttle, Ronald E. McNair. Prospective scholars represent a wide range of disciplines. These students share the common desire to pursue graduate studies, attain the doctorate, and join the ranks of the next generation of faculty members.

Program Components

The McNair Scholars Program provides exciting opportunities for undergraduate students at the junior and senior levels to prepare for acceptance into quality graduate programs of their choice. Program participants are provided services in academic skills, individual counseling support, and funded summer research internships. During the academic year a series of seminars provides information on graduate school financial aid, research skills and technical writing, the graduate school admission process, graduate school entrance exams, portfolio preparation, and more. Student concerns in financial, personal, and academic realms are addressed through individual counseling support services. Finally, the program offers participants site and mentors, provide workshops on research skills, help with report preparation, and assist as otherwise needed on an individual basis. At completion of the internship experience, McNair Scholars make formal presentations of their research to faculty and peers at the McNair Scholars Conference and submit papers summarizing their work. Opportunities to attend national research and graduate recruitment conferences and visits to other graduate campuses are encouraged and provided. Funded Internships

Research internships are offered to those Scholars who have earned at least 60 credits by the beginning of the internship period. Stipends for internships are awarded for an eight-week summer session. During the eight-week internship, students work 40 hours per week under the supervision of a faculty mentor and a graduate student advisor. Students seeking involvement submit an internship application to the program.

Eligibility and Selection

First generation students (neither parent has received a bachelor's degree) and income eligible, and/or from an underrepresented group (Black/African American, Hispanic/Latino, Native American, Alaskan Native, Native Hawaiian and Native American Pacific Islander). Have at least 50 credit hours Meet GPA requirements U.S. Citizen or permanent U.S. resident Committed to attaining their Ph.D.

Prospective participants are encouraged to contact the project staff for information and application materials at any time during the year. Participants are selected from undergraduate applications attending the University of Wyoming on the Laramie campus. Participation in the program is limited to 33 students.

Ronald Ervin McNair: The Man with a Mission

Ronald E. McNair, the second African American in space, was born on October 21, 1950 in Lake City, South Carolina.

While in junior high school, Ronald McNair was inspired by a teacher who recognized his science potential and believed



in him. He graduated as valedictorian from Carver High School in 1967. In 1971, he received his Bachelor's Degree Magna Cum Laude in Physics from North Carolina A & T State University (Greensboro). In 1976, at the age of 26, McNair earned a Ph.D. from the Massachusetts Institute of Technology (MIT).

While working with the Hughes Research Laboratory as a staff physicist, McNair soon became an acknowledged expert in laser physics.

NASA selected him for the

1978 space shuttle program and in 1984, McNair became the mission specialist aboard the flight of the shuttle Challenger. In addition, he received three honorary doctorate degrees as well as numerous fellowships and commendations.

Dr. McNair's life ended tragically on January 28, 1986 when the Challenger space shuttle exploded and crashed into the ocean, taking the lives of six other astronauts. After his death, Congress approved funding for the Ronald E. McNair Post-baccalaureate Achievement Program, which is dedicated to the support and promotion of the high standard achievement exemplified by McNair. The University of Wyoming McNair Scholars Program is dedicated to preserving his legacy of scholarship and accomplishments.

Forward by Project Director

There are a few words that I believe describe a McNair Scholar. The first word is courageous. As I see it, it is courageous for anyone to aspire to earn a doctoral degree. It requires **courage** to take a path not often traveled in our society, a path only 7% of college graduates ever complete, a path that is long for a journey that is often arduous. It takes courage to do something other people in one's family or community have not done before— courage to be different, to make your desires known, and to follow your dreams. With this courage, a student must also have **determination**. Often called, grit; it is one's ability to persevere through challenges using determination that sets our students apart. We ask a lot of our students. Undertaking a complex research project is by no means easy, and it is that determination which allows McNair Scholars to come out on the other side of eight weeks with a project ready for public presentation. Lastly, along with courage and determination, our McNair Scholars show **awareness**. Self-awareness and ability to reflect on their own personal journey is needed to cultivate success. We witness this awareness of self and reflection on one's journey each day as students work to complete projects and plan for their next chapters in graduate school.

This journal captures our McNair Scholars' courage, determination, awareness as well as the hours and hours of support they have received from mentors. With the help of faculty members and graduate students, our students are immersed in a research community of their own design. Without those who help through mentorship, their success would be impossible. One of the greatest joys of being a McNair staff member is the opportunity to work with the students, faculty members, and graduate students represented in this journal.

The McNair Scholars featured in this journal can be rightfully proud of what they have achieved. We wish them well and look forward to the great things they will achieve in their academic careers now and in the future.

Elizabeth Nysson, M.S.
Outgoing McNair Scholars Project Director



Tara Brunner

Faculty Mentor: Dr. Joshua Clapp

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Research Topic: Negative Appraisals as a Mediator for Behavioral Inhibition and PTSD

Introduction

Trauma resiliency is a heavily researched topic in clinical psychology, with a sizeable literature exploring individual difference factors which contribute to the resiliency against, or vulnerability to, the development of posttraumatic stress disorder (PTSD). Some evidence suggests that behavioral inhibition, a temperamental factor characterized by risk aversion and trait anxiety, may be associated with the development of PTSD following exposure to a traumatic event (Contractor, Elhai, Ratcliffe, & Forbes 2013; Asselmann, Wittchen, Lieb, Hofler, & Beesdo-Baum, 2015). However, few studies have examined potential intervening variables in the relation between behavioral inhibition and posttrauma symptoms. The aim of the current study was to examine the degree to which the negative appraisals may account for variability in the association between behavioral inhibition and PTSD symptoms.

Epidemiological research conducted over the past several decades indicates that traumatic experiences are common in the general population. A majority of people (60.7% of men and 51.2% of women; Kessler, Sonnega, Bromet, Hughes, & Nelson 1995) will undergo an event during their lifetime which would qualify as Criterion A event as defined in the DSM-5 (APA, 2013). However, estimated lifetime prevalence rates for PTSD are in the range of 6.4 to 6.8% (Kessler et al. 1995; Pietrzak, Goldstein, Southwick, & Grant, 2011), suggesting factors beyond exposure to a traumatic event are relevant in the development of chronic posttrauma symptoms. For example, demographic characteristics, such as being female or divorced, are associated with higher rates of PTSD (Kessler et al. 1995; Tolin & Foa 2008). Other psychosocial variables, such as elevations in interpersonal withdrawal, (Trickey, Siddaway, Meiser-Stedman, Serpel, & Field, 2012) and prior psychological

problems, (Xue, Gel, Tang, Liu, Kang, Wang, & Zhang 2015) are also associated with greater rates of trauma-related symptoms.

Behavioral inhibition is one such psychological variable which may function as a vulnerability factor for PTSD. Reinforcement sensitivity theory (RST) describes behavioral inhibition as an aspect of temperament which increases a person's avoidance of novelty and potential punishment (Gray 1987). While this process is believed to protect the individual through restraining potentially dangerous behaviors such as risky sexual practices, elevated levels are believed to cause general anxiety and overcautiousness. Greater behavioral inhibition also may potentiate negative feelings such as anxiety, sadness, fear, and frustration through the production of negative beliefs. Since behavioral inhibition is conceptualized as a broad temperament factor, it is expected to remain relatively stable over time. One commonly used index of this process is the Behavioral Inhibition Sensitivity (BIS) subscale of Carver and White's (1994) BIS/BAS measure. Individuals more sensitive to punishment and avoidance cues score higher on BIS and display these character traits more often.

The extant literature provides evidence of a robust association between behavioral inhibition and PTSD. Positive relations between these variables have been observed among survivors of a variety of traumatic events, including in trauma-exposed primary care patients (Contractor et al. 2013) and combat veterans (Myers, VanMeenen, & Servatius, 2012). Furthermore, Asselmann et al. (2015) conducted a longitudinal study investigating the role of behavioral inhibition in the development of PTSD in a community sample of adolescents and young adults. Investigators found that behavioral inhibition (measured between the ages of 14 to 17) was a reliable predictor of PTSD symptoms during the subsequent 10 years.

Behavioral inhibition demonstrates a meaningful association with PTSD, but the underlying structure of this relation remains unclear. Theories of both processes suggest an increased propensity for negative cognitions may serve as a functional link between these constructs. Models of temperament suggest behavioral inhibition may lead to general anxiety and fearfulness as a result of an underlying tendency toward negative appraisals (Gray 1987). Such cognitions are also believed to play a significant role in PTSD development, as indicated by a number of theoretical frameworks (Horowitz, 1986; Foa, Steketee, & Rothbaum 1989, Ehlers & Clark 2000).

Specifically, these theories emphasize the importance of negative thoughts about the self or the world, negative beliefs about symptoms following a trauma, and a perception of loss of self-control (Beck, Jacobs-Lentz, Jones, Olsen, & Clapp, 2014).

Preliminary data accords with these models, suggesting links between behavioral inhibition and PTSD may operate through negative appraisals. For instance, behavioral inhibition has evidenced correlations with maladaptive patterns coping following stressful events (Williams, Hundt, & Nelson-Gray, 2014). Participants high in behavioral inhibition demonstrated elevations in negative appraisals of stressful situations as threatening and uncontrollable. Furthermore, data indicate that negative assumptions about self-worth, self-control, and the benevolence of the world may be of particular importance to PTSD (Lilly & Pierce, 2013). Negative attributions in these domains were linked with posttrauma psychopathology among 911 telecommunicators.

Existing research suggests behavioral inhibition may serve as a vulnerability factor in the development of PTSD; however, few studies have examined the cognitive factors which may account for the functional relation between these variables. The current study examined negative beliefs about the benevolence of the world, self-worth, and self-controllability as potential intervening variables linking behavioral inhibition and PTSD. Undergraduate university students reporting a history of exposure to trauma in a preliminary survey were invited to participate in a larger project exploring functional outcomes following significant trauma. Behavioral inhibition was expected to demonstrate an indirect effect on posttrauma symptoms through indices of negative assumptions. Specifically, increases in behavioral inhibition were expected to be associated with elevations in negative attributions regarding self-worth, the benevolence of the world, and self-controllability, which were expected to relate to greater severity of posttrauma symptoms.

Methods

Participants

Participants were university students (N=188) enrolled in undergraduate psychology courses at the University of Wyoming. Students who reported past exposure to a traumatic event on a preliminary screening questionnaire were invited to participate in a larger study targeting functional outcomes

following significant trauma exposure. Those who enrolled in the larger project completed informed consent procedures and a comprehensive psychological assessment. Following the assessment, individuals completed several self-report measures evaluating temperament, cognitive patterns, trauma symptoms, and related constructs. All procedures received institutional review board approval.

Measures

Behavioral Inhibition/ Behavioral Activation Scales (BIS/BAS). The BIS/BAS is a 30- item self-report measure that evaluates behavioral activation and behavioral inhibition sensitivity (Carver & White 1994). Individual items load onto either the behavioral inhibition or behavioral activation scale and are rated on a four-point Likert scale (1=Very true for me; 4=Very false for me). Past research has indicated the BIS/BAS correlated strongly with similar personality constructs (BIS with neuroticism, BAS with positive affect; Campbell-Sills, Liverant, & Brown, 2004). Internal consistency of BIS scores for the current sample was 0.79.

World Assumptions Scale (WAS). The WAS is a 64-item self-report measure and is scored to evaluate problematic assumptions across eight individual subscales of four items each (Janoff- Bulman, 1989). The questions consist of a 6-point Likert scale (1=Strongly agree; 6= Strongly disagree). Three of the subscales measure beliefs regarding the Benevolence of the World, Self-Worth, and Self-Control. Higher scores on these subscales indicate greater levels of negative perceptions about the world, lower self-esteem, and higher levels of helplessness. Past research has indicated the subscales of the WAS are adequately reliable ($\alpha=.6$ to $.8$; Kaler et al., 2008). These scales also exhibited moderate-to-large relations with other measures of well-being (i.e, positive affect). Internal consistency for the current sample was 0.89 for the benevolence of the world, .87 for self-worth, and .71 for self-controllability.

PTSD Symptom Checklist for DSM-5 (PCL-5): The PCL-5 is a 20-item self-report scale evaluating symptoms of PTSD as outlined in the DSM-5 (Weathers, Blake, Schnurr, Kaloupek, Marx, & Keane, 2013). Participants ranked the extent to which they have been bothered by various symptoms over the past month on a 5-point Likert scale (0= Not at all, 4= Extremely). Total scores range from 0-80 and are calculated as the sum of all

individual items. Higher scores indicate more reported symptoms of PTSD. Past research has indicated the PCL-5 possesses acceptable reliability ($= .56-.77$; Sveen, Bondjers & Willebrand, 2016). It also demonstrated moderate to strong correlations with existing measures of PTSD ($.22$ to $.73$). Internal consistency for the current sample was 0.92 .

Analytic Strategy

Three models of indirect effect were used to examine the relations between behavioral inhibition and posttraumatic symptoms through the subscales of the WAS. For these analyses, BIS scores were modeled as the primary independent variable, with PCL-5-scores serving as the primary dependent variable. The WAS subscales of benevolence of the world, self-worth, and self-control were examined as intervening variables in successive models of the relation of behavioral inhibition with post-trauma symptoms. Behavioral inhibition scores were expected to be positively related to the scores on the WAS subscales, which are expected to positively relate to PCL-5 scores.

Intervening variable models were evaluated using Hayes' PROCESS macro for SPSS (Model 8; Hayes, 2012). Analyses conducted in PROCESS utilize bootstrapping methods to test the statistical significance of indirect effects. Bootstrapping procedures address known biases in traditional tests of mediation (e.g., Sobell, 1982) and are considered a best-practice approach for the evaluation of indirect effects (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). For the current study, bootstrapped confidence intervals were calculated for point estimates of indirect effects using 5000 resamples from the original data. Confidence intervals failing to capture a null estimate were interpreted as statistically significant. Effect sizes for individual regression coefficients are presented as partial (pr) correlations. Partial correlations represent the strength of a unique association controlling for other predictors in the model and served as a standardized index of effect. Values of $pr = .14$, $pr = .36$, and $pr = .51$ served as benchmarks for small, medium, and large effects, respectively (Cohen, 1988)

Results

Data Screening

Participants in the current study were undergraduate university students enrolled in psychology courses who

reported exposure to a traumatic event in a preliminary questionnaire. Of the original 194 participants, six failed to complete the online questionnaires and were eliminated from the present data. Of the remaining 188 participants, the majority identified as female (74.5%) and White/ Non-Hispanic (87%). The majority of participants reported sexual assault (36.1%) or a motor vehicle accident (23.5%) as their index traumatic event. Full demographic characteristics are presented in Table 1.

All data were screened before analysis to determine the concordance of scores with the assumptions of multivariate analyses. The distributions of BIS, WAS subscales of benevolence of the world, self-worth, and self-controllability, and PCL-5 scores demonstrated minimal skew and kurtosis ($\text{skew} \leq |2.00|$, $\text{kurtosis} \leq |2.00|$; Tabachnick & Fidell, 2013). Further screening identified little of concern with regard to linearity, homoscedasticity, or multicollinearity. Means, standard deviations, and correlations for primary study variables are provided in Table 2.

Model of Indirect Effect

Benevolence of the World: An initial model assessed the indirect effect of behavioral inhibition on PTSD through beliefs regarding benevolence of the world. Results are presented in Table 3. The relation between behavioral inhibition and benevolence of the world failed to reach criteria for statistical significance ($p = .352$). Beliefs about the benevolence of the world did demonstrate a reliable association with PTSD, consistent with a small to medium effect ($p < .001$; $pr = .290$). However, the bootstrapped confidence interval for this effect in the present data is not statistically significant ($ab = .066$; 95% CI $[-.066, .258]$).

Self-Worth: A second model assessed the indirect effect of behavioral inhibition on PTSD through self-worth. These results are presented in Table 4. Behavioral inhibition exhibited a statistically reliable, medium-sized effect on self-worth ($p < .001$; $pr = .390$). The relation between self-worth and PTSD was also significant and consistent with a medium to large effect ($p < .001$, $pr = .475$). Consistent with the hypothesized relations, the bootstrapped confidence interval for the effect of PTSD on behavioral inhibition through self-worth was statistically significant in this sample ($ab = .668$; 95% CI $[.412, 1.033]$).

Self-Controllability: A third model examined the indirect effect of behavioral inhibition on PTSD through feelings of self-controllability. Full results are presented in Table 5. The relation between behavioral inhibition and self-controllability was statistically reliable and consistent with a small effect size ($p = .025$; $pr = .163$). However, data failed to support a reliable association between self-controllability and PTSD ($p = .309$; $pr = .075$). The bootstrapped confidence interval for the indirect effect was not significant ($ab = .041$, 95% CI $[-.029, 1.67]$).

Discussion

The current study intended to examine the extent to which negative cognitions regarding the benevolence of the world, self-worth, and self-control served as intervening variables in the relation between behavioral inhibition and PTSD. Consistent with the hypotheses, an indirect effect of behavioral inhibition on PTSD through lower perceptions of self-worth was noted. The association of behavioral inhibition with self-worth beliefs is consistent with theoretical models of temperament (Gray, 1987). This framework indicates that individuals higher in behavioral inhibition are more sensitive to punishment, suggesting that individuals with elevated levels of behavioral inhibition may feel a decrease in self-worth over time. These reductions may follow punishment due to an individuals' sensitivity to these cues. Research also predicts that individuals higher in behavioral inhibition will display higher levels of neuroticism (Muris & Dietvorst, 2006). This sense of overall greater negative affect could contribute to lower perceptions of self-worth. Furthermore, the relation of self-worth to PTSD symptom severity is broadly consistent with cognitive theories of PTSD (Ehlers & Clark, 2000). These theories suggest traumatic events may confirm negative thoughts individuals exhibited before their traumatic experience. For instance, a person who believed the world to be dangerous before exposure, may add support to that belief after exposure. Since the values were collected at the same time in this sample, it is unknown if negative cognitions regarding self-worth precede or follow a traumatic experience, but the presence of negative cognitions of self-worth does appear to relate to PTSD severity. Finally, the self-worth subscale may be particularly relevant due to the relations of self-worth to feelings of guilt and shame. Both feelings play a role in PTSD symptomology (Resick & Schnike, 1992).

Contrary to the hypotheses, behavioral inhibition did not demonstrate a significant indirect effect on trauma symptoms through beliefs about the benevolence of the world. The lack of a relation between behavioral inhibition and the benevolence of the world may be due to the external nature of the benevolence of the world subscale. The benevolence of the world subscale contains items like "the good things that happen in this world far outnumber the bad". These items are consistent with appraisals regarding external events. Behavioral inhibition may affect more internal, personality-driven appraisals, such as the benevolence of people. It is possible that behavioral inhibition's aversion to punishment may cause more negative appraisals about other people rather than the world. Nevertheless, beliefs regarding the benevolence of the world did relate to PTSD severity. This may be because a traumatic event confirms negative thoughts an individual has about the world (Ehlers & Clark, 2000), or creates negative cognitions afterwards. Both of these situations could lead to increases in the individual's trauma symptoms.

Finally, self-controllability beliefs did not serve as an intervening variable in the relation of behavioral inhibition to PTSD. Results did indicate a significant relation between behavioral inhibition and perceptions of self-control. This is consistent with RST, which indicates that individuals higher in behavioral inhibition are more likely to interpret ambiguous situations as threatening (Gray 1987). This suggests individuals who interpret situations as more threatening may feel more helpless and deem themselves as incapable of dealing with the threats of life. However, self-controllability, as assessed by the WAS, did not relate significantly to PTSD. Most of the items on the WAS measure self-controllability as maximizing beneficial outcomes for oneself and protecting against negative outcomes. These measures may not fully capture feelings of helplessness as it relates to recovering from a traumatic event.

Interpretation of these results should be made in context of the current study's strengths and limitations. First, the sample available for the current study was sufficiently large to allow for detection of smaller effects, which is important in measuring effects in indirect analysis, which are notably small. The current study also obtained a sample of individuals exposed to true Criterion A trauma by selection through a prescreened survey and a thorough interview with trained

clinicians. This confirmation suggests that this sample displays true symptom of PTSD and should not be considered an analog sample.

Despite these strengths, the present research also exhibits relevant limitations. First, these data are cross-sectional, which limits conclusions regarding direction and causality of observed relations. A longitudinal study would allow for stronger conclusions to be drawn about the directionality of the relationships in the model. Furthermore, participants included university students not currently seeking psychological treatment. Such a nonclinical sample may be expected to be functioning at a reasonably high level, as they are able to attend university. A help-seeking sample may exhibit elevated levels of negative cognitions and higher PTSD symptom severity, producing stronger associations between negative appraisals and PTSD. Finally, the current study only examined three categories of negative appraisals. The scales were chosen based on theoretical models outlining probable relations with behavioral inhibition and PTSD. However, examining other kinds of negative cognitions may capture important variability in the relation between behavioral inhibition and PTSD. Other possible negative cognitions to investigate might be self-efficacy and benevolence of people. These scales may account for some of the statistically significant branches in the previous models while simultaneously accounting for additional variability in cognitions. For example, the benevolence of people subscale is similar to the benevolence of the world subscale' however, its different focus may explain further variance between these constructs.

Together, these data provide partial support for cognitive theories of PTSD in that they provide evidence for the role of perceptions of self-worth in the maintenance of PTSD. The significance of the self-worth subscale indicates targeting these cognitions specifically may improve therapeutic outcomes. Furthermore, understanding how behavioral inhibition relates to PTSD may allow researchers to develop methods to triage patients care following traumatic events, as those with elevated behavioral inhibition may exhibit a higher risk for developing PTSD.

Appendix

Table 1: Sample Characteristics (n=188)

	20.20
Age	(4.28)
Sex (% female)	74.5%
Race/Ethnicity	
Caucasian	87%
Hispanic	8.7%
African American	0.5%
Asian	2.2%
Other	1.6%
Index Event	
Sexual Assault	36.1%
Motor Vehicle Accident	23.5%
Physical Assault	11.5%
Suicide	5.5%
Combat	2.7%
Fire	2.2%
Threatened with a	
Weapon	2.2%
Illness	1.6%
Other	14.7%

Table 2: Means, Standard Deviations, and Correlations between Study Variables

Measure	Correlations				
	1	2	3	4	5
1: PCL-5	—				
2: BIS		—			
	0.263**				
3: WAS-Benevolence		0.068	—		
of World	0.297**				
4: WAS-Self Worth	0.525**			—	
		0.390**	0.385**		
5: WAS-Self	0.114**				—
Controllability		0.163*	0.152**	0.384**	
M	15.91	21.21	11.41	10.41	
					14.32
SD	13.2	3.83	4.54	4.76	3.61

Note: * = $p < .05$; ** = $p < .01$; *** = $p < .001$

PCL-5 = PTSD Checklist for DSM-5; BIS= Behavioral Inhibition Scale, WAS-Benevolence of the World = World Assumptions Scale: Subscale- Benevolence of the World; WAS-Self Worth= World Assumptions Scale: Subscale- Self-Worth; WAS-Self Controllability= World Assumptions Scale: Subscale- Self-Controllability

Table 3: Coefficients, Confidence Intervals, and Effect Sizes for Indirect Effects of Benevolence of the World

Outcome	Predictor	b(SE)	95% CI	p-value	pr
WAS-BW					
$R^2 = .005$	BIS (a)	.081(.087)	[-.090, .251]	.352	.068
PCL-5					
$R^2 = .148$	WAS-BW (b)	.815 (.198)	[.425, 1.205]	<.001	.290
	BIS (c')	.841 (.234)	[.379, 1.303]	<.001	.255
Indirect Effect	WAS-BW	.066 (.080)	[-.066, .258]		

Note: PCL-5 = PTSD Checklist for DSM-5; WAS-BW = World Assumptions Scale: Subscale- Benevolence of the World; BIS = Behavioral Inhibition Scale. Interpretive benchmarks for pr: small $\pm .14$, medium $\pm .36$, and large $\pm .51$

Table 4: Coefficients, Confidence Intervals, and Effect Sizes for Indirect Effects of Self Worth

Outcome	Predictor	b(SE)	95% CI	p-value	pr
WAS-SW					
$R^2 = .152$	BIS (a)	.483(.084)	[.318, .649]	<.001	.390

PCL-5

$R^2 = .279$	WAS-SW (b)	1.38(.188)	[1.01, 1.75]	<.001	.475
	BIS (c')	.24(.233)	[-.221, .700]	.306	.075

Indirect
Effect

WAS-SW	.668 (.156)	[.412, 1.033]
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Note: PCL-5 = PTSD Checklist for DSM-5; WAS-SW = World

Assumptions Scale: Subscale- Self Worth; BIS = Behavioral

Inhibition Scale. Interpretive benchmarks for pr: small $\pm .14$, medium $\pm .36$, and large $\pm .51$

Table 5: Coefficients, Confidence Intervals, and Effect Sizes for Indirect Effects of Self Controllability

Outcome	Predictor	b(SE)	95% CI	p-value	pr
WAS-SC					
$R^2 = .027$	BIS (a)	.121(.054)	[.015, .228]	.025	.163
PCL-5					
$R^2 = .075$	WAS-SC (b)	.339(.332)	[-.316, .993]	.309	.075
	BIS (c')	.866(.247)	[.379, 1.35]	<.001	.250
Indirect Effect					
	WAS-SC	.041 (.047)	[-.029, 1.67]		

Note: PCL-5 = PTSD Checklist for DSM-5; WAS-SC = World

Assumptions Scale: Subscale- Self Controllability; BIS =

Behavioral Inhibition Scale. Interpretive benchmarks for pr: small $\pm .14$, medium $\pm .36$, and large $\pm .51$

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Research Topic: Pancake Problem

Introduction

The traditional pancake problem was stated in [1] as follows:

The chef in our place is sloppy, and when he prepares a stack of pancakes they come out all different sizes. Therefore, when I deliver them to a customer, on the way to the table I rearrange them (so that the smallest winds up on top, and so on, down to the largest at the bottom) by grabbing several from the top and flipping them over, repeating this (varying the number I flip) as many times as necessary. If there are n pancakes, what is the maximum number of flips (as a function of n) that I will ever have to use to rearrange them?

In the traditional pancake problem, stacks of pancakes are represented by permutations in one-line notation. For example, a stack of size six would be represented as $[5\ 4\ 1\ 3\ 6\ 2]$, with 5 being the top number in the stack, and 2 being the bottom. A flip consists of a prefix reversal, i.e. reversing the order of the first k elements of the given list. The operation of flipping will be denoted as a vertical bar (i.e. $|$). Consider the following stack of five pancakes, $[3\ 5\ 1\ 4\ 2]$. For the given stack, there are five possible flips, leaving us with five different outcomes:

$$\begin{aligned} [3\,|\, 5\ 1\ 4\ 2] &\rightarrow [[3\ 5\ 1\ 4\ 2], \\ [3\ 5\,|\, 1\ 4\ 2] &\rightarrow [5\ 3\ 1\ 4\ 2], \\ [3\ 5\ 1\,|\, 4\ 2] &\rightarrow [1\ 5\ 3\ 4\ 2], \\ [3\ 5\ 1\ 4\,|\, 2] &\rightarrow [4\,|\, 5\ 1\ 3\ 2], \text{ and} \\ [3\ 5\ 1\ 4\ 2\,|\,] &\rightarrow [4\ 2\ 1\ 5\ 3]. \end{aligned}$$

In the pancake problem and its variants, flipping represents the only legal operation. At its simplest, the pancake problem consists of starting with a random stack of pancakes of size n , and ending with the sorted stack of size n . The sorted stack, denoted as the identity stack, will take the form of

$(1\ 2\ \dots\ n-1\ n)$, where the top most pancake is one, and the bottom most is the n^{th} term, with the middle being sequential from left to right. An interesting question that naturally arises then is given a stack of n pancakes, what is the minimum number of flips needed to order the stack? This number corresponds to the pancake number. For example, consider $[2\ 3\ 4\ 1]$, a stack of four pancakes. For this stack, the following sequence of moves is one way to sort it. $[2\ 3\ 4\ 1] \rightarrow [4\ 3\ 2\ 1] \rightarrow [1\ 2\ 3\ 4]$. Observe that each flip done in the previous example brought us closer to the solution, allowing us to efficiently move towards the identity stack. This efficient process of sorting a stack of ordered pancakes is known as the pancake number for that stack. Note that with the previous stack of pancakes we could do no better than 2 moves, thus the pancake number for that stack of pancakes is 4. This notion introduces an interesting idea. Does each pancake stack of size four have a pancake number of 2? The brief answer is no, there are stacks that have a pancake number of one, two, or three. Thus, the pancake number for a random stack of n pancakes is more difficult to calculate. For a general stack of n pancakes, the pancake number will correspond the maximal value of the upper bound for that specific n value. The pancake number for a stack of n pancakes is known for $n \leq 19$ [5]. However, beyond that, little is known. To fill this gap in the knowledge, focus was given to specific variants of the traditional pancake problem. These variants focus on few pancake sizes but have no restriction to the size of a stack of pancakes. This paper covers the Binary Pancake Problem, as well as the Ternary Pancake Problem.

Terminology and Notation

We begin with some needed definitions. First of all, each stack of pancakes within the variants is given as an n -tuple. An n -tuple is an ordered list of n symbols. The only operation we have in this problem is flipping, which is consistent with a prefix reversal, as defined in the introduction. In this discussion, permutations are not used, and thus group theoretic properties do not apply. In this discussion, the terms Binary, Ternary, and so on are treated as being strict, meaning there must be one of each symbol present in each tuple. For example, a binary pancake stack of size 6 could be $[0\ 1\ 0\ 1\ 1\ 0]$ and a ternary pancake stack of the same size could refer to $[2\ 1\ 2\ 2\ 1\ 0]$. Note that each stack does not necessarily have an equal number of symbols present in each n -tuple. In the spirit of these variants, the identity stack must also be discussed. For example, for the binary pancake problem the identity stack is an n -tuple of the form $[0\ 0\ \dots\ 0\ 1\ 1\ \dots\ 1]$. Another important distinction within these problems is the notion of bounds The

terms *upper bound* and *lower bound* refer to the maximum and minimum number of moves required to sort a stack, respectively. These terms are critical tools for examining any form of the pancake problem, allowing us to gauge not only how well we are sorting stacks of pancakes, but also to guide us towards a minimized solution for each stack. Additionally, the term *bad pair* is integral to the analysis of the binary pancake problem. It refers to an adjacency of two pancakes that are not the same size, denoted as $a \sim b$, where a and b are elements of the given stack. Also, if the bottom value in a given stack of pancakes is not the largest value in that stack (i.e. 1 for binary pancake stacks, 2 for ternary pancake stacks...) then this also counts as a bad pair. For example, consider a binary stack of the form $[0\ 1\ 0\ 0\ 1\ 0]$. Looking for bad pairs, we find that there are six of them: $[0 \sim 1 \sim 0 \sim 0 \sim 1 \sim 0]$. It is worth noting that for a pancake stack of n symbols, it will have exactly 1 bad pair if and only if it is sorted. For example, a stack of n binary pancakes will have one bad pair in the identity stack, i.e. $[0\ 0\ \dots\ 0 \sim 1\ 1\ \dots\ 1]$. As previously discussed, the *pancake number* for a given stack is the minimum number of flips it takes to sort the stack. In section 4, we will see a discussion of the binary pancake problem, including the upper bound, lower bound, and the binary pancake number.

Basic Algorithms

Throughout this research, a common problem persisted. For each size of pancake stacks I wanted to examine, I would have to hand write each possible combination. For small n -tuples this wasn't a burden, however, as I began to explore larger sizes this task ate up much of my time. Thus an algorithm was designed to generate the possible stacks of a given size, for two symbols. This algorithm, given in Figure 1, helped ensure that each n -tuple was generated, allowing the results developed in sections 4 to be more accurate. Using SAGEMATH, a computational cloud service, the algorithm in Figure 1 was written in Python. For the sake of simplicity, only one variable must be input to the algorithm.

Using the input command `Binary Tuples( $n$ )` at the end of the code results in the algorithm producing n^2 binary n -tuples. Note that this algorithm does not sort the n -tuples it generates, it simply presents them in a usable, one-line notation. For example, an input of `Binary Tuple(4)` gives the results given in Figure 2. Note that the larger the n used, the longer this algorithm will take to compute each t -tuple.

```

def Binary_Tuples(n):
    if(n==0):
        return [[]];
    if(n>0):
        B1=[[0],[1]];
        B2=Binary_Tuples(n-1);
        B3=[];
        for b2 in range(len(B2)):
            for b1 in range(len(B1)):
                C3 = B2[b2]+B1[b1];
                B3.append(C3)
        return B3;

```

Figure 1: This algorithm can be used to generate the desired binary n-tuples.

```

[[0, 0, 0, 0], [0, 0, 0, 1], [0, 0, 1, 0], [0, 0, 1, 1],
 [0, 1, 0, 0], [0, 1, 0, 1], [0, 1, 1, 0], [0, 1, 1, 1],
 [1, 0, 0, 0], [1, 0, 0, 1], [1, 0, 1, 0], [1, 0, 1, 1],
 [1, 1, 0, 0], [1, 1, 0, 1], [1, 1, 1, 0], [1, 1, 1, 1]]

```

Figure 2: Binary Tuples(4) output

The Binary Pancake Problem

The binary pancake problem is the variant that I heavily explored in this research. For clarification, the binary pancake problem consists of the typical flipping operation, with exactly two distinct symbols given in an n-tuple. For example, a few 5-tuple binary pancake stacks are the following; [1 1 0 1 1], [0 1 0 1 0], and [0 1 0 0 1]. For a given n, the number of possible binary pancake stacks is given by $2^n - 1$. Note that the stack size for this problem is unrestricted, hence the n-tuple. To begin, the upper bound and lower bound are explored followed by a discussion about the binary pancake number.

Binary Pancake Problem Upper Bound

Theorem 1 For a given stack of n binary pancakes, the maximum number of flips to sort a stack of n binary pancakes it is given by $n - 1$.

Proof.

Suppose that we have any stack of n binary pancakes denoted as Γ . Let α and β denote the two distinct sizes of pancakes, and let a sorted stack be represented by $[\alpha \cdots \alpha \beta \cdots \beta]$. Begin by examining the stack Γ for bad pairs. Since the stack is binary, it starts as $[\alpha \alpha \cdots \alpha \beta \beta \cdots \beta \alpha ? \cdots ?]$ or $[\alpha \alpha \cdots \alpha \beta \beta \cdots \beta]$, denoting the length of the strings of α 's as k and the string of β 's as ℓ . In the latter case, then it tuple is ordered. Otherwise, flip about the line between the first β, α to get $[\beta \beta \cdots \beta \alpha \alpha \cdots \alpha \alpha ? \cdots ?]$, denoting the length

of the new string of α 's as $\hat{k}$ and the new string of β 's as $\hat{\ell}$. In this new stack, we now have that $\hat{k} + \hat{\ell} > k + \ell$. Note that if done correctly, each flip will reduce the number of bad pairs by one. Since initially $n + m \geq 2$, and the stack is sorted when $\hat{k} + \hat{\ell} = n$, we will repeat this process at most $n - 2$ times before we get to a sorted stack. It may take one more flip to get the stack in non-decreasing order. Hence every binary stack of n pancakes can be put in sorted order in at most $n - 1$ flips.

Consider the stack Γ of the form $[\beta \alpha \beta \cdots \alpha \beta \alpha]$. Counting the bad pairs within Γ , we will have $\ell = n$ bad pairs. Using the above process, we will use exactly $n - 1$ flips to order the stack, due to the guarantee of reducing the number of bad pairs by exactly one each time. Therefore, there are at most $n - 1$ flips needed to sort the given stack Γ . $\square$

Binary Pancake Problem Lower Bound

Before we discuss the lower bound for the binary pancake problem, consider the following problem. Consider having a bank account with \$101 in it. The bank you use has no limit to the amount of money you can deposit at one time, but they restrict withdrawals to \$1 per visit. Suppose you wish to have an ending balance of \$2, how many times must you visit the bank to accomplish this? Immediately one might think that it will take exactly 99 visits, however, what if you go to the bank and deposit another n dollars? Well, it would then take at least $99 + n$ visits to the bank to reduce your account balance to \$2. In layman's terms, you must take at least 99 visits to the bank to accomplish your goal, you simply cannot do any better. Moving forward the examination of the binary pancake lower bound is built under the same logic.

Theorem 2 Let Λ be a stack of n binary pancakes. Then the minimum number of flips to sort it is given by $\ell - 1$, where ℓ is the number of bad pairs in that stack.

Proof.

Let α and β denote the two distinct sizes of pancakes, and let the identity stack be represented by $[\alpha \dots \alpha \beta \dots \beta]$. To begin, examine Λ , the given stack of binary pancakes. Looking into the stack, count the number of bad pairs and let that be equal to ℓ . Note that each time you flip a binary stack of pancakes such as Λ , you can decrease the value of ℓ by at most one. Since the final stack will have one bad pair, and Λ has ℓ bad pairs, then apply the logic used in the above foot note. Hence it will take at least $\ell - 1$ flips to go from ℓ bad pairs to 1, since one can only decrease the number of bad pairs by 1 for each flip. Therefore, the minimum number of flips is given by $\ell - 1$. $\square$

The Binary Pancake Number For A Given Stack

Theorem 3 For a given stack of n 0's and 1's, denoted by Γ , it's the binary pancake number is given by $\ell-1$, where ℓ is the number of bad pairs in the stack.

Proof. Suppose that we have any stack of n binary pancakes, Γ . Then for the stack Γ , count the number of bad pairs, denoted as ℓ . If $\ell \geq 2$ the stack is not sorted. We then apply the following algorithm: Start by finding the left most bad pair. Then find the next bad pair from the left, and flip between that pair. This decreases the number of bad pairs by exactly one for each flip. Repeating this process until the number of bad pairs in Γ is one, we will have made exactly $\ell-1$ flips. Therefore, the binary pancake number for a given stack of pancakes is $\ell-1$. $\square$

The Binary Pancake Number For n Pancakes

Theorem 4 Let $\{\Gamma_n\}$ denote the set of all binary pancake stacks for a given n . Then the binary pancake number for $\{\Gamma_n\}$ is given by $n-1$.

Proof. Suppose that we have a set of binary pancake stacks of size n , denoted as $\{\Gamma_n\}$. Within this set, we have a large variety of pancake stacks. Going from stack to stack, note that the maximal number of bad pairs in any stack is exactly n . Then by Theorem 1, we know that stacks of this type take exactly $n-1$ flips to sort. Because $\{\Gamma_n\}$ contains all binary pancake stacks of size n , we are guaranteed to have at least one that will take $n-1$ flips to sort. Thus the binary pancake number for a set of pancakes of size n is $n-1$. $\square$

Higher Order Pancake Problems

Thus far in this research, we have thoroughly explored the binary pancake problem. I feel that the results found are sufficient, and as efficient as possible. However, moving forward there are several other variants I would like to examine. First off, the ternary pancake problem introduces a dynamic not seen in the binary pancake problem. In the ternary problem, you are not guaranteed a flip each time that will reduce the number of bad pairs within the given stack of n ternary pancakes. This dynamic will no doubt be present in pancake problems involving four or more pancakes for a stack size of n . Examining the number of times this flip must be done could lead to further insight into the traditional pancake problem. As seen with the binary pancake problem, there really is no relationship between the number of symbols used and the stack size. Consider a pancake problem where n pancakes are used and $\frac{n}{2}$ col-

ors are present, rounded to the nearest integer value. Coining this problem the Chromatic Pancake Problem due to the fact that the colors would be sorted in a chromatically consistent way. This problem in itself adds several levels of complexity, allowing us to examine a problem that is closely related to the traditional pancake problem. How could we relate the bounds of the traditional pancake problem to the bounds for the chromatic pancake problem? How much do they have in common? Can we use the results from examining the chromatic pancake problem to expand what is known for the traditional pancake problem? Another question that comes to mind is if $\frac{n}{2}$ is the best choice for comparison to the the traditional pancake problem. Would examining $\frac{n}{m}$, for $1 < m < n$ result in a better comparison? All of these questions seem to be a rich area of study within the realm of pancake problems and need heavy investigation.

Conclusions

In conclusion, this research has explored a few variants of the traditional pancake problem, with some success. To further these results, more examination must be done into other variants of the traditional pancake problem. By continuing this examination further insight can be developed, allowing a deeper understanding of the traditional pancake problem, along with its variants.

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Research Topic: An Investigation into the Presence of Light Absorbing Particles in the Snowy Range

Introduction

In the discussion of climate change, or in particular anthropogenic climate change, one key idea takes shape, carbon dioxide. Carbon dioxide is one of the most well-known and studied greenhouse gases and is known to contribute significantly to global warming worldwide. In 2014, CO₂ accounted for about 80.9% of all U.S. greenhouse gas emissions from human activities (National Research Council, 2011). Carbon dioxide is largely contributed to atmospheric greenhouse gas concentrations through human activity largely by the combustion of fossil fuels. The combustion of fossil fuels, biofuels, and burning of biomass is also known to contribute significantly to the presence of Light Absorbing Particles (LAP's) in the atmosphere. LAP's are emitted in the form of fine particle matter (PM) into the atmosphere and are the most effective form of PM at absorbing solar energy (Report to Congress on black carbon: Department of the Interior, Environment, and Related Agencies, Appropriations Act, 2010. n.d.).

Once in the atmosphere, LAP's have a short-lived life before removal via dry- deposition, or wet-precipitation processes. LAP's, much like carbon dioxide are a climate-forcing agent; LAP's and dust reduce snow and ice (snow-ice) albedo by absorbing solar radiation, which leads to increased melt and sublimation rates (Warren and Wiscombe, 1980). LAP particulates have been documented in South America, North America, the Poles, and the Himalayan region as a contributing factor to accelerated melting of glacial ice, permanent snowfields, and accelerated snowpack melting (Hadley, Corrigan, Kirchstetter, Cliff, Ramanathan, 2010) (Li et al., 2016) (Painter et al., 2013) (Schmitt et al., 2014). The reduction of snow-ice albedo from LAP deposition leaves the world's valuable resources of water contained in snow-ice at risk (Barnett, Adam, Lettenmaier, 2005).

Snow-ice is among the most reflective of natural surfaces on Earth. Addition of dark impurities decreases its reflectance, also

known as albedo, and increases its absorption of solar energy (Hadley, Kirchstetter, 2012). LAP deposition is a major factor for the rapid disappearance of arctic sea ice, mountain glaciers, and snow packs (Hadley, Corrigan, Kirchstetter, Cliff, Ramanathan, 2010). Unlike the effects of carbon dioxide contributing largely to greenhouse gas concentrations and the subsequent rise in global temperatures, the effects of LAP's are noticed on a more regional scale (Ramanathan, Carmichael, 2008). Well over half of the world's potable water is extracted directly from rivers, or stored in reservoirs for future usage. The discharge of these rivers is sensitive to long-term changes in both precipitation and temperature, particularly in the snowmelt-dominated parts of the world (Barnett, Adam, Lettenmaier, 2005). The largest forecasted areas that will be affected rely heavily on seasonal snow-pack and glacial runoff as the main source of water (Baraer et al., 2012).

Mountain snowpack in western North America is a key component of the hydrologic cycle, storing water from the winter and releasing it in spring and early summer, when economic, environmental, and recreational demands for water throughout the West are frequently greatest. In most river basins throughout the West, snow melt is one of the largest seasonal contributors of fresh water; the West is vulnerable to climatic variations and changes that influence spring snowpack (Mote, Hamlet, Clark, Lettenmaier, 2005). As currently seen in the western United States, the increasing annual temperatures paired with LAP deposition on snow-ice bodies is leading to peak run-off occurring earlier and water resources becoming stressed earlier (Flanner et al., 2009). This problem is occurring in other regions of the world like the Himalaya, and Tropical Andes, both regions that supply water to large population centers (Li et al., 2016) (Schmitt et al., 2014).

The direction and magnitude of surface temperature changes are much more consistent among climate models than are precipitation changes. Near-surface air-temperature predictions from existing global climate models that are forced with anthropogenic increases in atmospheric greenhouse gas concentrations imply a high degree of confidence that future changes to the seasonality in water supply will occur in snowmelt dominated regions (Barnett, Adam, Lettenmaier, 2005). Rising carbon dioxide emissions leading to rising annual global temperatures, paired with carbonaceous aerosols, is creating a feedback loop of negative effect on regional water sources. With more than one-sixth of the Earth's population relying on glaciers and seasonal snowpacks for their water supply, the consequences of these hydrological changes for

future water availability-predicted with high confidence and already diagnosed in some regions-are likely to be severe (Barnett, Adam, Lettenmaier, 2005).

Light Absorbing Particles, or Black carbon, Brown Carbon, soot, and dust, are the primary byproducts in the combustion of fossil fuels. LAP's are emitted in the form of fine particle matter into the atmosphere (Andreae, Gelencser, 2006). The main sources of LAP's come from the incomplete combustion of fossil fuels, biofuels, biomasses, fires (wildfires, agricultural fires, heating practices), and surface mining of coal. These aerosols absorb and scatter solar radiation in the atmosphere and in snow-ice masses (Ramanathan, Carmichael 2008). Terminology in the field of carbonaceous aerosols uses LAP's as a term to illustrate the optical properties of these different forms of soots and dusts. Soot containing carbon particles is made up of combusted carbon, or carbon particles resembling combustion, and organic matter (brown carbon, humics, and bioaerosols). The graphitic content and organic content within these soots is generally grouped together and coined with the term LAP or BC in association with the light absorbing properties (Andreae, Gelencser, 2006). LAP's are commonly defined in an operational sense as the absorbing component of carbonaceous aerosols, which may result in some humic-like or other organic material contributing to estimated BC absorption (Hansen, Nazarenko, 2004).

Concentrations of carbonaceous aerosols in the atmosphere vary regionally with hotspots in the Tropics and East Asia due to developing nations in these regions (Ramanathan, Carmichael, 2008). The transportation of these aerosols relies upon Earth's weather and climate system with precipitation and wind being the driving forces of this transportation and deposition. The lifetime of carbonaceous aerosols held within the atmosphere is dependent on climate conditions, but it is believed that these forms of PM are deposited out of the atmosphere rapidly (Haywood et al., 2008). Once in the atmosphere, carbonaceous aerosols absorb and scatter energy and can heat the atmosphere by absorbing energy via heating the surrounding air and clouds. On snow-ice the absorption and scattering of solar energy takes place leading to decreases in the broadband spectral albedo of snow-ice. Radiation-transfer calculations indicate that seemingly small amounts of LAP's in snow-ice, of the order of 10-100 parts per billion by mass, decrease its albedo by 1-5% (Hadley, Kirchstetter, 2012). The main purpose of this study is to evaluate the winter to spring snowpack of the Snowy Range for the presence of Light Absorbing Particles. If LAP's are determined to be present in the snowpack, then the

quantification of the concentrations of LAP's present in the snowpack will be completed. Finally, the concentrations will be applied to a Snow, Ice, and Aerosol model (SNICAR) to evaluate the albedo effects upon the Snowy Range's snowpack.

Methods:

In the atmosphere, LAP's are captured using special collection instruments carried by airplanes, helicopters, and other flying vehicles. Sampling of LAP's on the surface is manually conducted in the field, often in remote harsh environments like the Andes or Himalayas. On the surface, LAP's can be collected by capturing precipitation or sampling surface collections of precipitation like snow-ice. These samples are collected or filtered through specific sieves and filters that capture the LAP concentrations and can be later analyzed with further techniques. In this study, the technique of collection used by the "Soot in Arctic Snow" group (Doherty et al., 2010) and Dr. Schmitt of the American Climber Science Program (Schmitt et al., 2014) is employed with some minor updates in the sampling procedures.

During the study, snow samples are collected from a predetermined location in the Snowy Range (see Figure 1). This location was selected to target the area's unique geography and weather patterns. The 3661.87-meter-tall Medicine Bow Peak splits the Northern end of the Medicine Bow Range, running southwest to northeast and creates a division with Wyoming Highway 130. The sampling location is approximately 9.65 kilometers due east of the Summit of Medicine Bow Peak in an open field. The criteria of the sample site was chosen to remove the addition of natural and unnatural contaminants, snowmobile exhaust, natural carbon deposits (trees, plants, surface dust). The site captures the general westerly weather flow of wind and precipitation common to this location in the winter-spring months. The eastern slopes of Medicine Bow Peak become heavily wind-loaded with snow due to the strong winds common with this mountain range (Hiemstra, Liston, Reiners, 2002). This area lacks present day glaciers and permanent snowfields; however, the heavy seasonal snow it receives leads to a strong spring snowpack in the region.

The field sampling site is encompassed in an area that seems devoid of large-scale LAP sources, like a coal-burning power plant. However, two large open-surface coal mines exist west of this location (about 209 kilometers West). The remote alpine location of this site, especially in the winter-spring months due to the seasonal highway closure, was a determining factor for the selection of this site. All samples were collected over an elevation of 3048 meters. This factor's role is to target large

snow deposits that do not disappear throughout the winter-spring. The similarities of this field site were selected to be compared to another ongoing study in the Wind River Mountain Range of Wyoming.

Sampling procedures were conducted on the surface of the snowpack and were followed to create a simple sampling procedure (see Figure 2). Starting in December of 2016, samples were taken on an average bi-weekly schedule with targets aimed at collection of recent snowfall and old deposits of snow; sampling was concluded in April of 2017. The field site was reached via ski travel; each sampling day was conducted in the same manner, GPS waypoints being taken and recorded along with altimeter readings. Basic weather and snowpack condition observations were taken upon each sampling date and recorded as field notes. These notes probed the depth and composition of the snowpack and compared observed weather conditions with known weather station reports.

Samples were collected from the surface and beneath the surface, with increments of surface measurements taken 2.5 centimeters under the immediate surface to remove any surface contaminants; the sub-surface samples were taken 15 centimeters under the surface. Snow samples were collected by scooping snow with an avalanche shovel into a sterile-food safe 4-litre Ziploc bag. The bags were labeled on the outside with a permanent marker. Samples were then transported to a cooler in a vehicle for storage during the transportation of the samples to a freezer unit in the front country. Typically, snow is collected with a shovel that has been "contaminated" with local snow; this is done by washing the sampling instruments with local snow so that any contaminants on the shovels are similar to those in the snow (Schmitt et al., 2014).

Once in the front country snow samples were kept frozen until they could be melted at a further date. Generally, snow samples are melted one at a time by placing the sealed Ziploc bags in warm water (usually around 30C). Once completely melted to a liquid homogenous mixture the snow-water was drawn into a 60 mL syringe and pumped slowly through 0.7 micron "Pallflex Tissuquartz" type 25 mm quartz fiber filters. A target of 600 mL was filtered through each sample filter unless the filter became too clogged; in this case, less water was filtered (see Figure 3). Each sample's volume of filtered water was carefully recorded for use in further analysis. The samples were filtered immediately after melting to reduce the adhesion of particles to the sides of the plastic bags. It typically takes 20-30 minutes from beginning of melting of a sample to completion of filtering. Filters were removed from filter holders, placed in plastic capsules designed for coin collections,

and held in place with a foam ring. The filters are dried and stored in a freezer to reduce the growth of any organisms (see Figure 4).

Analysis

Analysis of the collected particles on the quartz filters was conducted with the help of Dr. Carl Schmitt, an atmospheric scientist at the National Center for Atmospheric Research (NCAR). Dr. Schmitt is the inventor of the Light Absorption Heating Method (LAHM). The LAHM is an instrument designed to quantify the optical light absorption properties of the particles collected on the filters. Since snow-ice is completely absorptive of the thermal infrared wavelengths, the instrument is designed to investigate the relationship of snow-ice within the visible light range. The goal behind measuring Light Absorbing Particles in snow is to understand the amount of visible light energy that particles can absorb. This is crucial in understanding how the mass loads of these particles can lead to increasing melt rates and sublimation in snow-ice.

The LAHM instrument exposes the particles to visible light, which leads to the particles on the filters absorbing the optical energy and heating up. An infrared thermometer records the temperature of the filter every second and records the data to a computer. The LAHM runs through a 10 minute cycle of exposing the particles to light and cool down periods, this creates an average of the temperature fluctuations (see Figure 5). The instrument has been calibrated with known masses of LAP's, so with this data the masses of the LAP's collected in the Snowy Range can be directly correlated. More information on the LAHM can be accessed from Dr. Schmitt's 2014 paper on the LAHM (Schmitt et al., 2014).

Results:

Results from the LAHM are expressed in a measurement referred to as effective Black Carbon (eBC). The values of eBC are expressed in a ratio of nanograms of LAP particles to grams of water or snow; this directly translates to a parts per billion (ppb) measurement. As seen in the results from the sampling conducted from December 2016 to April 2017 in the Snowy Range, we see values with similar concentrations and low concentration values throughout most of the winter months. However, as the onset of spring begins, the values taken from the surface show a departure from the average. Measurements taken from the surface and sub-surface show similarities throughout the winter months, but during the spring months we see a departure in the form of the surface samples yielding higher concentrations. In this study, low values come in

at 2.1 ng/g eBC, with highs at 26.8 ng/g eBC, and an overall average of 11.84 ng/g eBC (see Figure 6).

Comparison to Wind River Range

When looking at a different data set collected over a three-year period from another remote alpine environment in the state of Wyoming, there are noticeable differences in eBC values. An on-going study collecting snow-ice samples from the Dinwoody and Gannett Glaciers in the Wind River Mountain Range in west-central Wyoming yielded much higher values. Over three years the averages start in 2014 at 49.13 ng/g eBC, 2015 53.83 ng/g eBC, and 2016 131.49 ng/g eBC. The much larger values seen in the Wind Rivers are likely due to the snow-ice that is being sampled, never fully melting out seasonally. This is due to the samples having been collected from a glacier that has year round snow coverage. However, in the Snowy Range the snowpack disappears annually.

SNICAR Modeling

The data generated from the LAHM technique was then modeled to simulate how these particles affect the broadband spectral albedo of the snowpack in the Snowy Range. The Snow, Ice, and Aerosol Radiation model (SNICAR) (Flanner, Zender, Randerson, Rasch, 2007) was used in this study to determine the effects of LAP's on the broadband spectral albedo of the Snowy Range snowpack. The data was first modeled with un-uniform conditions present. These variables in the model reflected the field observations of weather and snowpack conditions collected throughout the study period. With highly variable conditions, the results show a constant departure in broadband spectral albedo from the winter to the spring months (see Figure 7). Next, the model was applied with uniform conditions, or constant variables of weather and snowpack conditions. This was done to simulate the particles effects on the snowpack's broadband spectral albedo if there was zero variability in the snowpack. This helps to show a better image of what these particles can do to a snowpack altogether. This simulation showed a more constant effect on the snowpack and yields a 1% decrease in the broadband spectral albedo of the Snowy Range snowpack (see Figure 8).

Conclusions

The study conducted in the 2016/2017 winter-spring months in the Snowy Range's of Wyoming shows that Light Absorbing Particles are present in the mountain range's snowpack. However, the values found at an average of 11.84 ng/g eBC are under the typical North American average of 30 ng/g eBC (Schmitt et al., 2014). In terms of these particles' roles as climate forcing agents upon the Snowy

Range snowpack, the results show a more positive outlook than the results of the on-going study being conducted on the Wind River Range's last remaining large-glaciers. During this study, a sourcing technique utilizing Raman Spectroscopy was employed to try to source the composition of the particles found, further investigating using this technique will be used to try and source the particles composition. The stark difference in data collected from the Snowy Range in regards to the Wind River Range is likely due to the ability of the Snowy Range's snowpack to annually disappear and reset, where as in the Wind's the samples are being collected from a receding glacier that every year is becoming more exposed. The presence of dust is likely a large contributor to the LAP's found in the Snowy Range due to the windy nature and direction of Wyoming in relation to the field site.

Further expansion of this research in the future is necessary. With a larger area of access, numerous field sites, larger sample sizes, installation of auto collecting stations, and the ability to source the particles' composition, this study can be useful for state and federal land and water management programs. By better understanding the presence and effects of LAP's in the Snowy Range, a more developed plan to understand peak water runoff, management the snowpack, and water collection techniques can be developed for use by State and Federal officials that manage the water and land associated with this area.

Figures

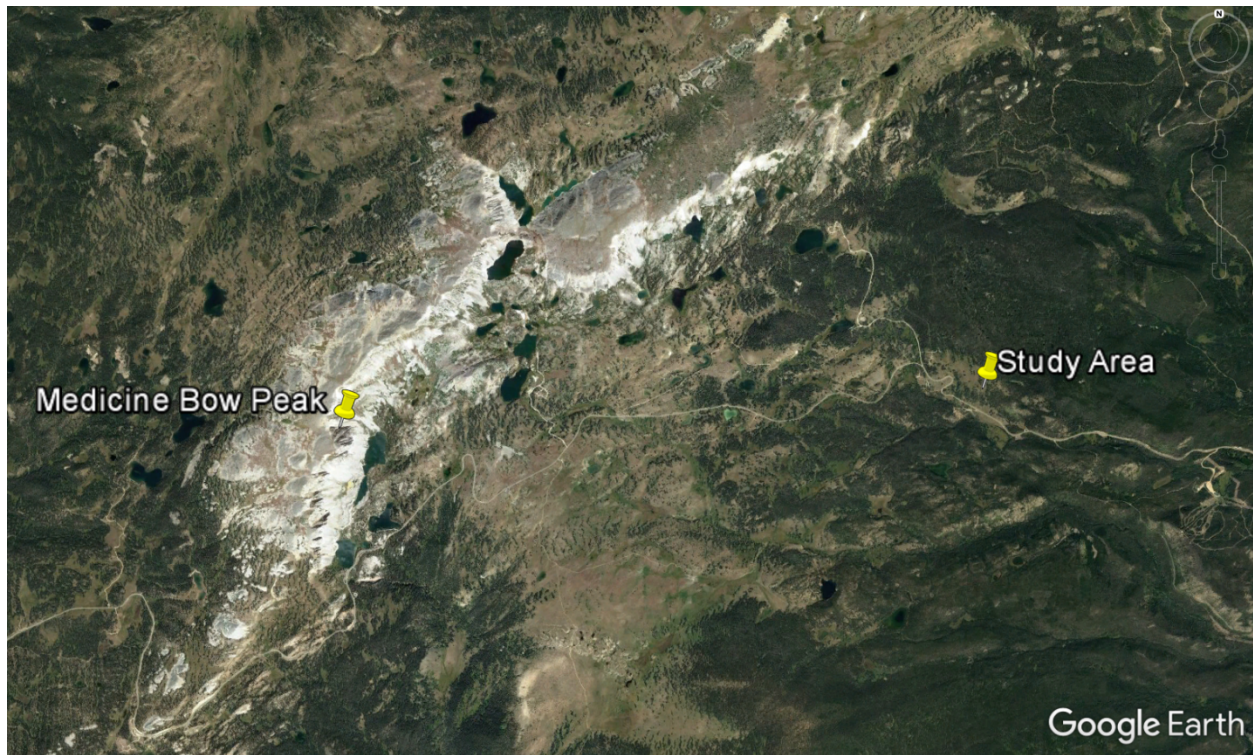


Figure 1



Figure 2



Figure 3



Figure 4

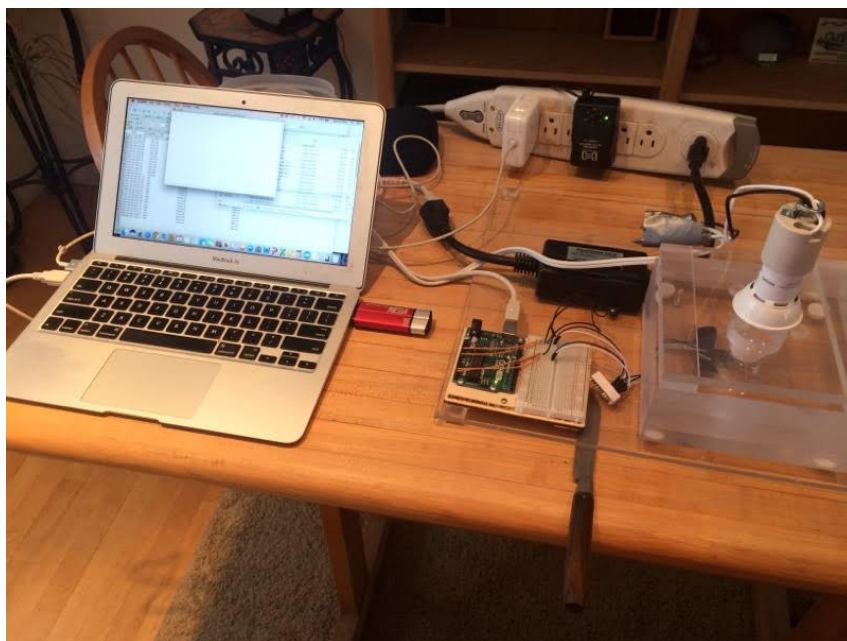


Figure 5

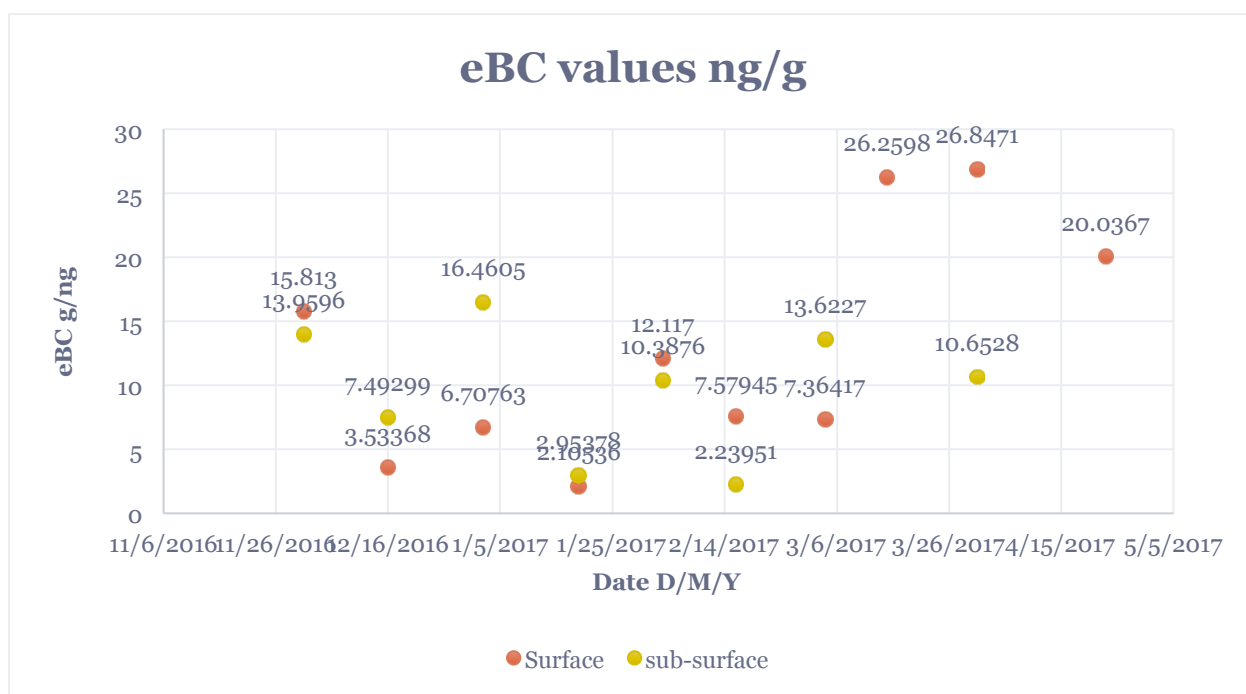


Figure 6

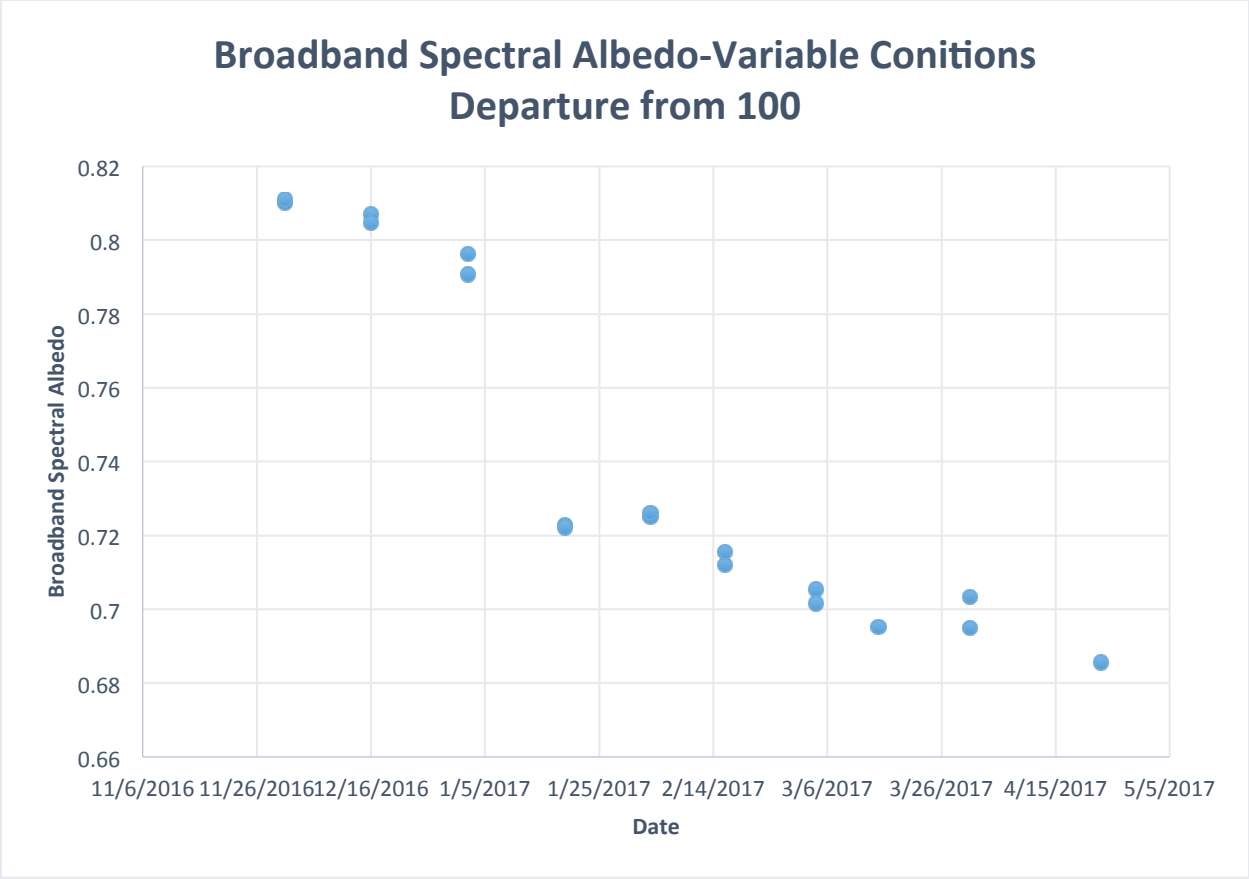


Figure 7

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Research Topic: Settlement Dynamics of the
Cajamarca Valley in Northern Peru

Introduction

The Cajamarca Valley is situated in the highlands of Northern Peru at an altitude of 2,600–4,000 meters above sea level. This paper will discuss the period spanning from 1400B.C. to A.D. 1532, and the changing settlement patterns we can observe within the valley. During this nearly 4,000 year time span, humans were moving around the valley based on different elements essential for their survival, whether that was because they needed more defensible locations or they needed agricultural fields. Utilizing Geographic Information Systems (GIS) technology and settlement data collected by previous archaeologists (Julien 1988, Seki 2003, and Wester 2000). This paper seeks to illuminate these shifting settlement patterns and add to Peruvian archaeology for a better understanding of the Peruvian cultural background.

Past archaeological settlement pattern analysis using GIS in Peru has neglected the Cajamarca Valley. In his book, Michael Moseley discusses much of how the Inca Empire became the largest native state to arise in the western hemisphere and the largest empire of antiquity ever to develop south of the equator (Moseley 1992). Moseley (1992) goes on to explain how the Inca Empire falls to the Spanish conquistadors in A. D. 1532 with the death of their emperor, Atahualpa Yupanqui in the city of Cajamarca. Although the Inca Empire spanned more than 5,500 km less than 40,000 individuals made up the actual 'Inca' group. The rest of the people within the Inca Empire were known as their subjects who fell under their rule by force of arms (Mosely, 1992). This means that although the city of Cajamarca was a vital place for the Inca Empire the Cajamarca people were not Inca and therefore archaeologists have not studied the Cajamarca people much outside of their role with the Inca Empire. Jeffrey Quilter again goes over the arching timeline of all of the Andes; however the author goes into more detail about important developments period by period (Quilter 2014). This author

does not go into detail about each culture just the major ones during the different time periods. Both the books mentioned above are good sources for the Inca Empire or the overall timeline of the Andes, but they do not go into great detail about the Cajamarca Valley because it was not as important until nearly the end of the Cajamarca Culture itself and the Inca Empire. These books also do not explain settlement patterns and systems.

Kent V. Flannery, does explain settlement systems and settlement patterns. A settlement system is the set of rules that generated a settlement pattern in the first place. Settlement systems cannot be empirically derived, but at least some of the rules can be deduced by simulation or other models that have their own problems. A settlement pattern is a pattern of sites on the regional landscape. Patterns are usually studied by measuring site sizes, counting sites, measuring the distance between sites and others (Flannery 1976). This author describes different site typologies that come from workers in the Valley of Mexico. Flannery's list of site typologies stem from previous work done by Jeffery Parsons and Richard Blanton where they set about providing a longer and more detailed series of definitions of settlement types in their study area in Formative Mesoamerica. Although this author clearly has what a settlement system and settlement pattern is, his work was done in Mesoamerica and not in the Cajamarca Valley. Another book written by Ian Hodder and Clive Orton mainly focuses on the potential for more methodical studies of spatial patterning with archaeological data. The authors discuss how earlier studies were inadequate with distributions of artifacts in regard to trying and establishing prehistoric trade routes, for example, the subjectivity involved in map interpretation (Hodder and Orton 1976). John Kantner wrote an article that discusses the history of regional archaeology and the ground-breaking projects that helped contribute to what is known as "New Archaeology" in the mid-1960's (Kantner 2007). The definition of regional analysis is also so varied that it is hard to pin down what exactly what one archaeologist is saying compared to another. This is a big problem today, because using GIS tools is so new it is hard to run spatial analysis on an area and have it be copied to a different area and get similar results that have similar meanings. Another article written by Stephen A. Kowalewski discusses the inconsistency of regional settlement analysis. Most of his data comes from Eastern Europe and is based off old ways of conducting archaeological surveys (Kowalewski 2008). There have been settlement pattern studies in Peru, just not in the Cajamarca Valley.

Although there is newer information, Toohey 2012, out about the Cajamarca Valley there are still gaps in this information. For example no one has yet to gather all the data that is out there about every site in the Cajamarca Valley and do spatial analysis on it. Seki (2003) and Julien (1998) have surveyed the valley and found many sites as well as providing some detail about each site. Data collected from a dissertation written by Dan Julien in 1988 gives us more sites to compare with roughly 129 sites. However this data was recorded in the early 1980's and is skewed about 420 meters to the Northwest. Although this dissertation has lengthy paragraphs about each site that would be useful in spatial analysis with the data being off from where it is supposed to be it is hard to actually do spatial analysis without correcting the data itself to put sites where they really are on the ground (Julien 1988). Even with these long paragraphs for each site there is still information lacking about how the sites changed sizes over time. There are sizes for each site, but that size is based on what is on the ground today and not what the size was when the site had people there. There have been archaeologists who have done detailed work but only on certain sites. For example Jason Toohey wrote an article about a certain site in Cajamarca, Yanaorco. The article states that Yanaorco was a major population center during the Late Intermediate Period. There is also evidence of two different social strata at this site. This article is helpful because it helps break down different components of the site and allows us to see the data that proves it is from the Late Intermediate Period (Toohey 2012). Although this article breaks down different components of this site it is only based on one site and does not give any other information on other sites. There are several sources on Andean archaeology, but they all mainly focus on the Inca Empire. The archaeologists who are doing their work in Peru do cover the span of the entire human history in one form or another, but no one has focused on the Cajamarca Valley itself. There have also been many studies on GIS in archaeology, but many of them are older and out of date with today's new technology. When a study has been done in the Cajamarca Valley itself studies have concentrated on single sites or were done before GIS technology was operating like it is today.

This original research utilizing GIS spatial analysis tools will produce important settlement data that will allow the comparison of human settlement between Cajamarca and other Andean regions. The Cajamarca Valley is located in Northern Peru and is surrounded by mountains on nearly all sides with the geographically dominate access point to the Southeast. The Chonta River enters the

valley from the Northeast and the Mascón River enters from the Northwest (Julien, 1988). These two rivers join and form the Cajamarca River which flows out of the valley into the basin and eventually ends up flowing into the Amazon River (Figure 1). Because of poorly drained soils, agriculture is limited in large areas of the basin. Fields were terraced and settlements most likely shifted around the valley based on access to agricultural fields and pasturage. The patterns of archaeological sites found in the valley show these shifting locations and this project seeks to identify patterns by looking at particular site attributes including: attributes including location, site size, site elevation, and site type.

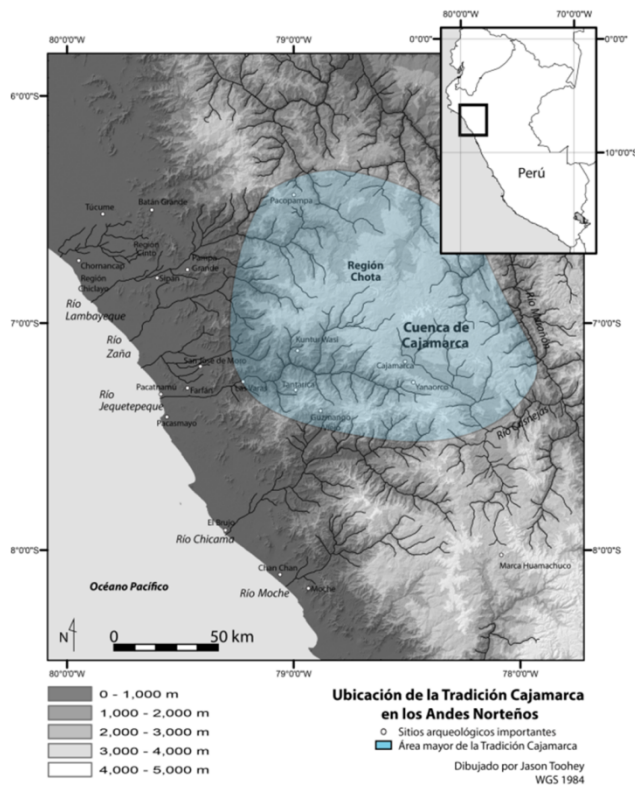


Figure 1: Map of northern Peru indicating location of the Cajamarca Culture. Figure Produced by Dr. Jason Toohey.

The Cajamarca Culture

The Cajamarca Valley was first occupied during what is known as the Early Huacaloma time period from 1400B.C.-1000B.C. This time period lasted for approximately 400 years. Following the Early Huacaloma time period is when the Late Huacaloma (1000B.C.-400B.C.) time period begins, more people

move into the valley at this time and we see more sites appear in the valley (Julien, 1988). The Layzón Period (400B.C.-200B.C.) follows and is the last time period before we see artifacts from the Cajamarca Culture start to appear during the Initial Cajamarca Period from 200B.C.-A.D.100. After the Initial Cajamarca Period comes the Early Cajamarca (A.D.100-A.D.500), Middle Cajamarca (A.D.500-A.D.850), and Late Cajamarca (A.D.850-A.D.1200) Periods. During Final Cajamarca (A.D.1200-A.D.1532), we see many new developments. For example, in A.D. 1460, the Inca Empire conquers the city of Cajamarca and the whole valley comes under its rule (Quilter, 2014). The city of Cajamarca was not only a provincial

capital, but was an administrative center for much of Northern Peru for the Inca Empire. Then according to Quilter (2014) in A.D.1532, the Spanish conquistador Francisco Pizarro kills the Inca Emperor in Cajamarca effectively ending the Inca Empire and ending the Cajamarca Culture before the Spanish influence.

When an area comes under the influence of different political or religious entities the people already living there will shift their locations depending on their need to defend themselves or give in and contribute to the larger group. Also being at such a high elevation these people needed to move based their accessibility to agricultural fields or their flocks of camelids. From this information several research questions can be asked,

1. Are sites clustered? Or more randomly located?
2. Do settlement patterns change significantly between chronological time periods?
3. Do settlements move to higher elevations or to lower elevations?
4. Do the ratios of different kinds of sites change through time?
5. For those sites for which we have areas, can we see the formation of site size hierarchies over time?

Hypothesis

Due to archaeological sites being in both higher and lower elevations and either being reoccupied or continuously occupied throughout the different time periods, it is hypothesized that people moved around based on the accessibility to agricultural fields and pasturage, while also moving to more defensible locations during times of conflict. Figure 2 shows a hypothetical and generalized pattern of what we would see if there was a system with strong political or religious integration. The bigger site might be a political administrative center or ceremonial center. This means that commerce and trade would have been the focus in an administrative center while worship would have been the emphasis at a ceremonial center. The sites would be clustered around these centers and would not be randomly placed. Figure 3 is what we would see if sites were chosen based on their proximity to a roadway, river, or other linear feature on the landscape. During the Inca rule of the Cajamarca Valley, they had to communicate with others outside the valley and roadways were created for easier passage in and out of the valley so during the Final Cajamarca time period we would expect to see some sites lined along these roadways created by the empire (Quilter, 2014). Figure 4 is what we would see if there was no political or religious integration in place. Sites would be randomly scattered and would most likely be of similar

size because they did not have influence over one another. Alternatively, a settlement pattern where the sites are evenly separated and spaced from one another might also imply conflict and competition between these sites (Flannery, 1976).

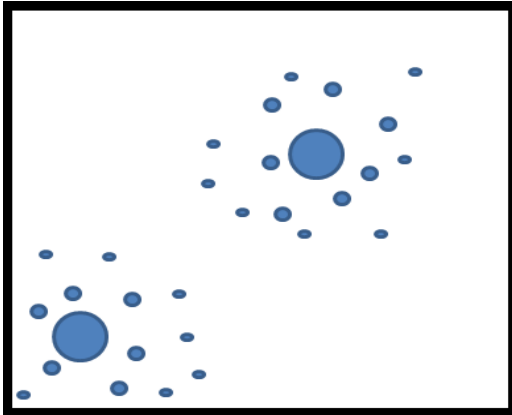


Figure 2: A centralized hierarchy of settlements might imply the presence of political or economic integration in the region. Large central sites might hold influence over smaller sites.

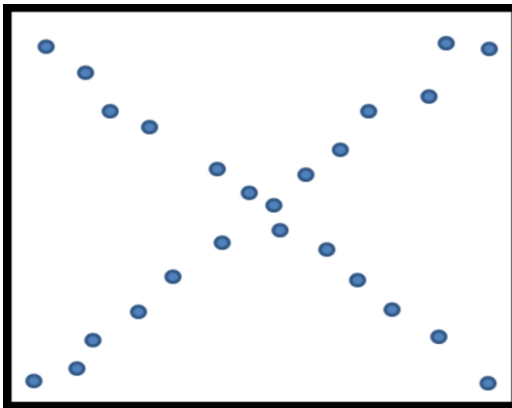


Figure 3: Linear location of settlements may indicate economic relations between sites, may also indicate placement along roads or waterways.

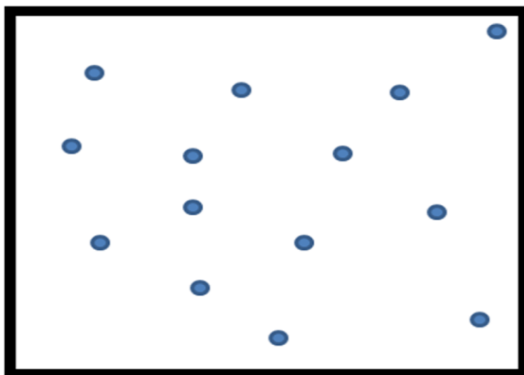


Figure 4: Relatively random location of settlements may imply a lack of political or economic integration.

Methods

A review of published literature on Peruvian archaeology, the central Andes, and GIS in archaeology determined the need for spatial analysis in the Cajamarca Valley. Site location information was gathered from the published sources of Dan Julien (1988), Yuji Seki (2003), and Carlos Wester (2000), and compiled into one

database in Microsoft Excel and then imported into a GIS program called ESRI ArcMap. Before being imported into ArcMap, the data needed to be cleaned making it uniform. Two of the sources were translated from Spanish and had to be converted from Degree, Minutes, Seconds into Decimal Degrees in Lat/Long then converted again into UTM coordinates so that all the data is in the same coordinate system. Once all the data was in the same coordinate system, I was then able to import it all into ArcMap. However some of our data did not line up because it was recorded in the early 1980's, prior to the common use of handheld GPS units. This meant that the data needed to be moved and in order for that to happen we needed to see how far off the points were from known locations and the other archaeologists' data when both had recorded the same site. For the most part the sites lined up with one another, but when they did not, a decision had to be made judgmentally to select the best one that would give us the most information possible. I utilized spatial analysis tools in ArcMap to run different calculations and determine different aspects of settlement based on the locations, size, and other information of sites. One spatial analysis tool ran is called the Nearest Neighbor analysis. According to ESRI the Nearest Neighbor tool "measures the distance between each feature centroid and its nearest neighbor's centroid location" (ESRI 2016). Then it averages all these nearest neighbor distances. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed is considered clustered. This tool ran an analysis on every time period to determine if there was a clustering of sites. Another analysis ran was the Central Feature analysis, this tool runs analysis on all the sites to determine where the central site is for each time period. The Central Feature tool identifies the most centrally located feature in a point, line, or polygon. As stated by ESRI "distances from each feature centroid to every other feature centroid in the dataset are calculated and summed, then the feature associated with the shortest accumulative distance to all other features are selected and copied to a newly created output feature class" (ESRI 2017).

Results

The first map (Map 1) seen here is a map indicating all recorded sites from all time periods. As you can see from the map, there are multiple administrative centers and ceremonial centers; larger circles indicate larger sites. The Early Huacaloma Period from 1400B.C.-1000B.C. has few sites and is closer to the entrance of the valley. Given the z-score of 3.282, there is a less than 1% likelihood that this dispersed pattern could be the result of

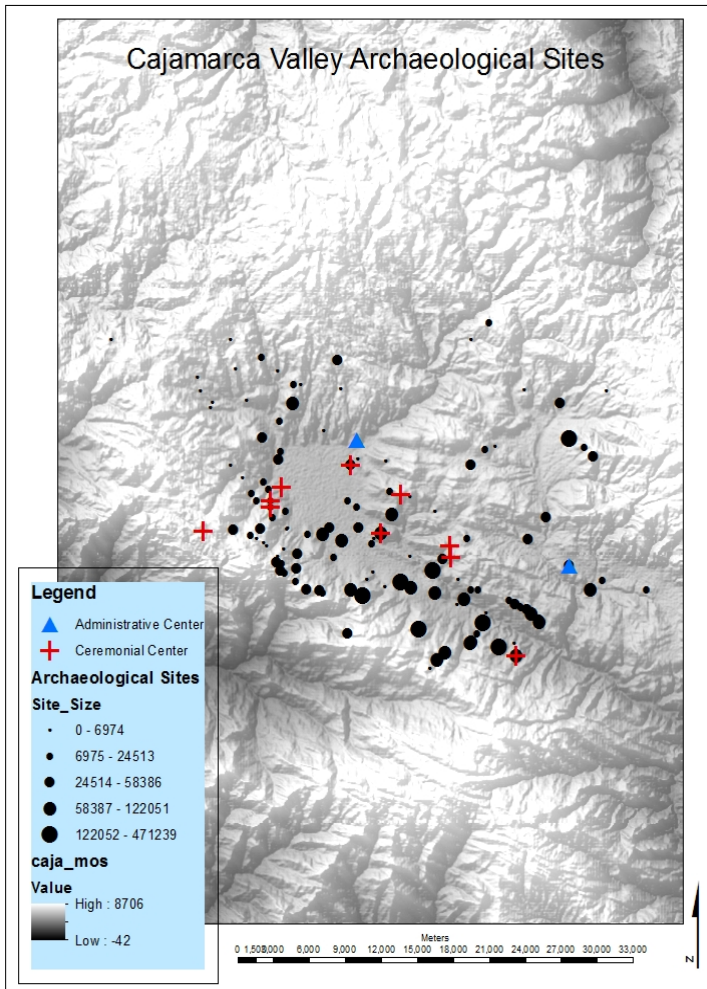
random chance during the Early Huacaloma Period. (Map 2) The Late Huacaloma spans from 1000B.C.-400B.C. and has more sites (Map 3). An interesting result from this time shows that the sites are clustered and given the z-score of -2.459, there is a less than 5% likelihood that this clustered pattern could be the result of random chance. As indicated in Map 4 by the green dots this set of smaller sites are clustered around two ceremonial centers. These two ceremonial centers, Santa Apoloina and Agua Tapada, were very important during this time so it is no surprise that other sites clustered around them (Quilter, 2014). They are also the largest sites within the small cluster; as we would expect to see. We would expect to see this pattern based on studies done by previous archaeologists. For example Hodder and Orton mention several people who have used different criteria such as size to examine the spatial relationships of settlements. Salway, Hallam and Bromwich (1970) used size to cluster different sites together and by doing so was able to tell the larger sites from the bigger sites and how they interacted with each other (Hodder and Orton 1976). As time goes on, more and more sites appear in the valley, with more ceremonial centers, but it is not until the Early Cajamarca Period (A.D.100-A.D.500) that an administrative center appears (Map 5). The number of sites can be counted off of ArcMap after being imported from the primary sources of Julien (1988), Seki (2003), and Wester (2000). This means that sites were first organized around ceremonial centers and the system in place was more religious then as more people come into the valley a political system developed that began organizing the valley. Again given the z-score of -2.455 from the Nearest Neighbor analysis, there is a less than 5% likelihood that this clustered pattern could be the result of random chance. More sites appear until the Late Cajamarca when suddenly there are fewer sites and they are not organized (Map 6). The larger sites move to higher elevations and it seems like there is no political or religious integration in place and given the z-score of -0.742, the pattern does not appear to be significantly different than random. The Final Cajamarca Period (A.D. 1200-A.D. 1532) again sees more sites and becomes organized under the Inca Empire (Map 7) and with a z-score of -6.457, there is a less than 1% likelihood that this clustered pattern could be the result of random chance. This system lasts until the Spanish conquest, effectively ending the Cajamarca culture (Julien, 1988).

Conclusions and Future Work

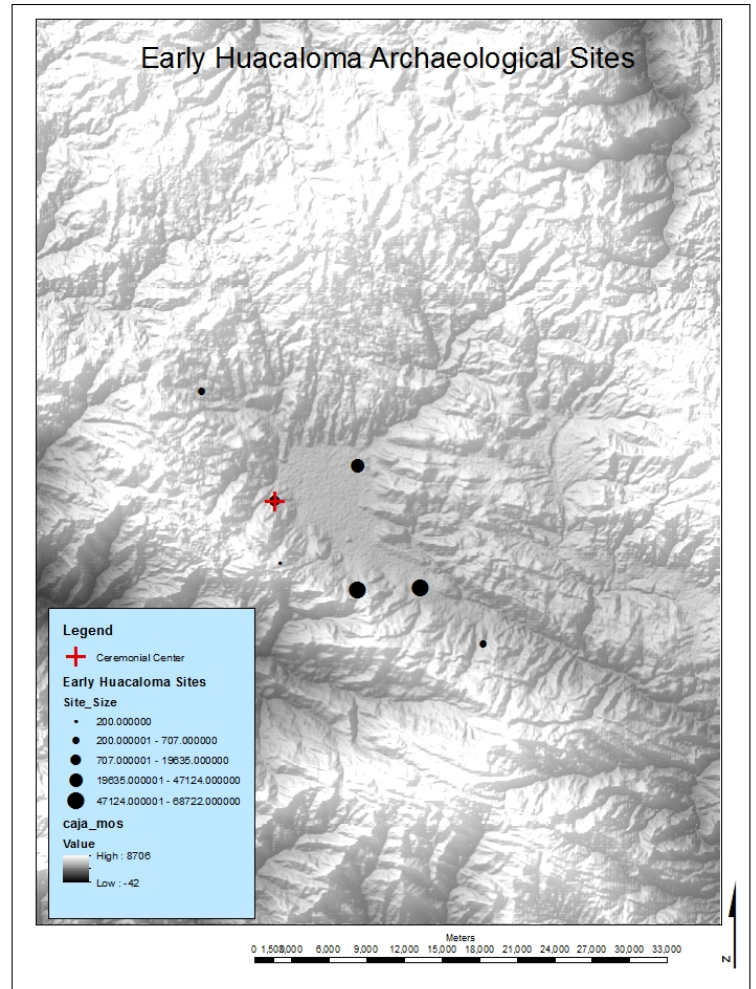
The Cajamarca culture settlement patterns shifted around the valley during the span of 4,000 years. They would move based on their need for pasturage and accessibility to agricultural fields

or they would move to higher locations that were easily defended. These results are just the beginning of what we are finding. There are still different analysis, Viewshed analysis and Least Cost analysis, we would like to run and will do so in the coming months as we continue our research. However because this data was collected during the early years of GIS and not collected by us personally there are questions that may not be answered unless new data is collected. Our next step with analysis will include a Viewshed Analysis of important sites from each time period. This means we will pick sites that were important during each time period and see what these sites could see within the valley. For example the sites of Agua Tapada and Santa Apolonia were important during the Late Huacaloma Period so the Viewshed Analysis would be used to determine if other sites could be seen from those two. We will also be doing least cost analysis out of the valley to other data we have that is north of our study area. This means we will find a central point or important site within the Cajamarca Valley and use the least cost analysis to determine what the easiest way to get from the valley to the data from Wester (2000) is. We are also hoping to look at elevation and what role that played in the decision making of these people to move around. Our research is still ongoing, but from the results we already have we can begin to understand how people were moving around in the Cajamarca valley.

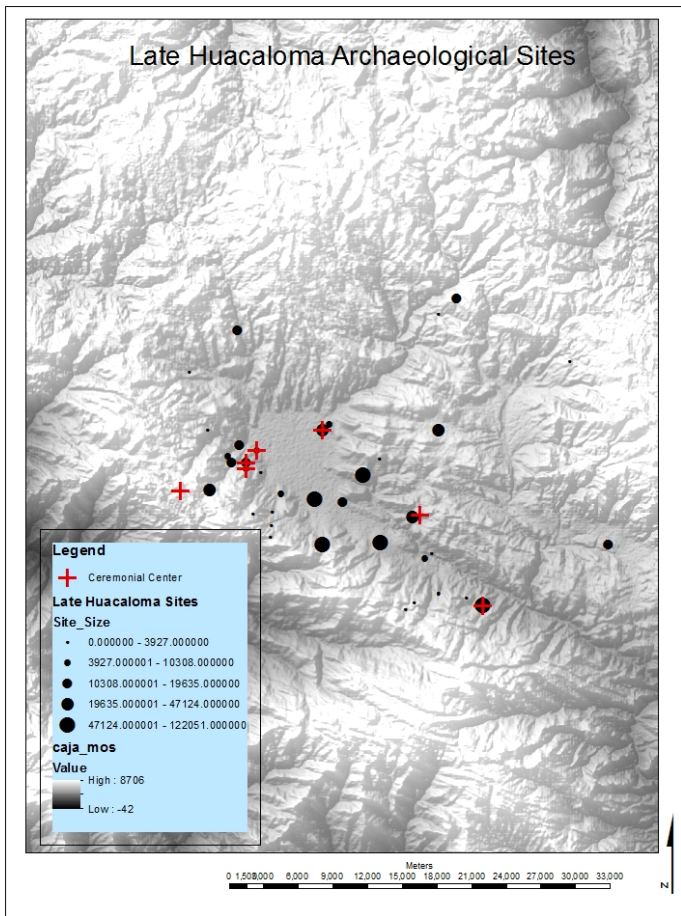
Map 1



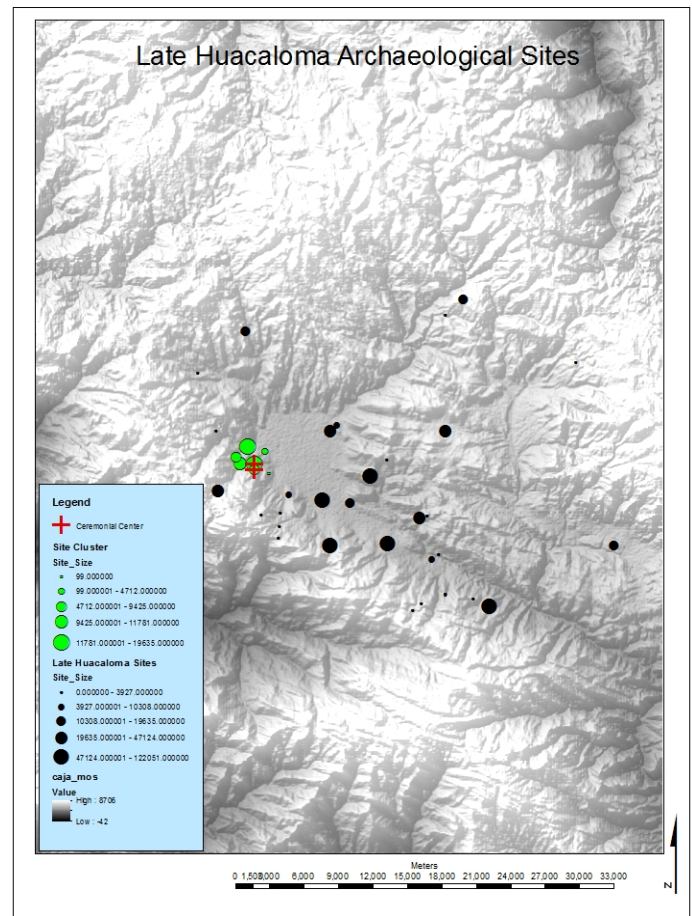
Map 2



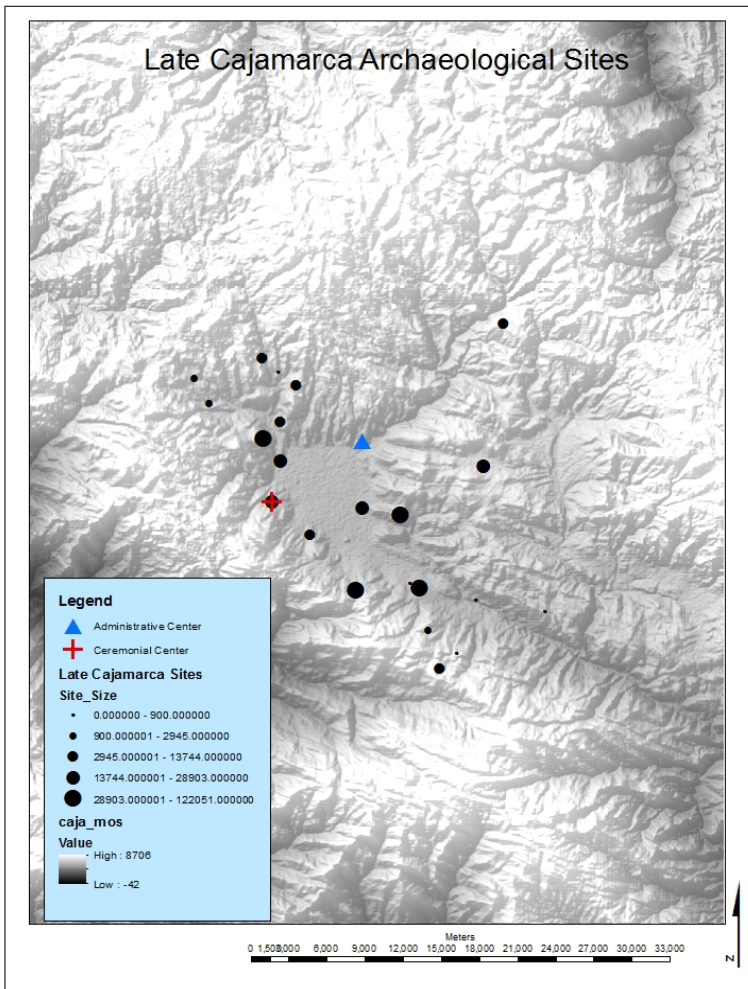
Map 3



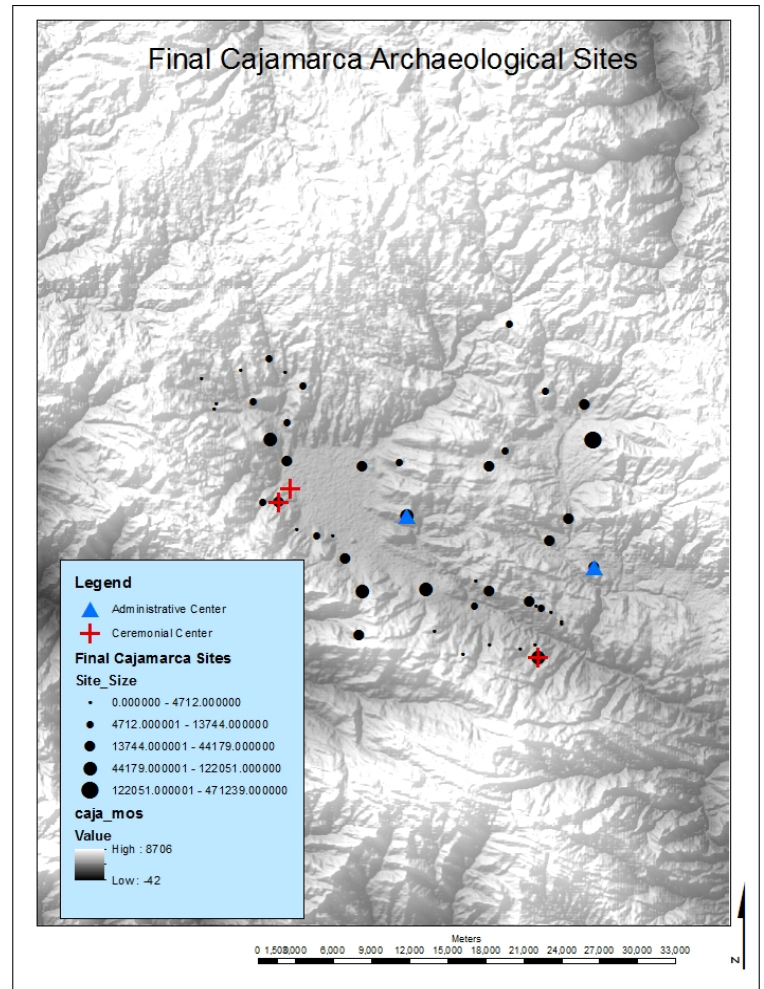
Map 4



Map 5



Map 6



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Research Topic: Community Partnerships for Addressing Domestic Counterterrorism: A Case Study of Denver and the Front Range

Introduction

Understanding and preventing terrorism in the world and, more specifically, in the United States, has been a focus of policy and researchers particularly since the terrorist attacks on September 11, 2001. Both international and domestic strategies have been developed to address the problem. Domestically, one of the primary threats of domestic terrorism is homegrown (FBI 1). American citizens take measure into their own hands, whether they be for social or political objectives, and carry out attacks on U.S. soil. According to a report made possible by the U.S. Government Accountability Office (2017), "from Sept. 12, 2001, to Dec. 31, 2016 – there have been 85 attacks in the country by violent extremists resulting in 225 deaths (Valverde, 2017). The threat that emerged following the attacks on September 11, 2001 allowed for the creation of several policies, institutions, agencies, and organizations at all levels of government that aid in counterterrorism. These policy responses range from working specifically with Muslim communities and profiling to community-based counterterrorism programs which is the subject of this project. Such community-based programs are intended to build awareness and implement prevention programs within communities, while working closely with local law enforcement.

This study investigates community-based partnerships and provides a specific analysis of the community partnerships between the government, private, and public sectors in Denver and the Front

Range. It questions how effective community partnerships are in fighting terrorism and how and why they can counter domestic terrorism. Its goal is to understand and evaluate efforts regarding community-based counterterrorism in order to aid in the broader study of effective counterterrorism strategies. Prior to evaluating these community partnerships for addressing domestic counterterrorism, it is helpful to gain perspective by examining security and counterterrorism before 9/11, the landscape of policy after 9/11, and the nature of domestic terrorism in the United States and the reasons community partnerships are needed.

Review of Literature and Nature of the New Terrorism Challenge after 9/11

In order to get a better understanding of the nature and scope domestic terrorism poses, prior to looking at and evaluating these community partnerships which address domestic counterterrorism, it is first helpful to start by examining security and barriers to counterterrorism before 9/11, the landscape of policy that followed after 9/11, and the nature of domestic terrorism in the United States, and the means for which community partnerships are needed.

Barriers to Counterterrorism: 9/11 and its Aftermath

A primary task for government is the protection of its citizens from external threat. The events of September 11, 2001 brought home that the United States was vulnerable to a new kind of non-state threat which would require an adjustment in its policies to address. Prior to 9/11, security agencies involved in counterterrorism were primarily the Federal Bureau of Investigation (FBI) and the intelligence community. the FBI was the leading agency in strategic domestic counterterrorism efforts. According to the *Law Enforcement, Counterterrorism, and Intelligence Collection in the United States prior to 9/11 staff statement No. 9* (2004), the FBI played a role in domestic counterterrorism, but the approach was traditional. Agents were taught and trained to build cases geared toward prosecution. "Agents developed information in

support of their own cases, not as part of a broader, more strategic effort. Given the poor state of the FBI's information systems, field agents usually did not know what investigations agents in their own office, let alone in other field offices, were working on" (Boyd, 2004). In sum, developing and understanding the international terrorist threat, which were seen in the attacks on 9/11, would have been very difficult given the constraints of law enforcement priorities and practices. The FBI, like many agencies, was unable to synthesize the information that foreshadowed a terrorist attack and therefore failed to provide an effective prevention strategy (9/11 Commission, 2004).

Amy Zegart, co-director at the Center for International Security and Cooperation (2005) argues the information on the 9/11 attackers was available but not put together. In her article, she notes that 20 months before the attacks on 9/11, the Central Intelligence Agency (CIA) had identified Khalid al-Mihdhar, one of the hijackers from American Airlines flight 77. The CIA knew his full name, his passport number, and that he had several visas to enter the United States. Khalid, among other Al Qaeda operatives gather for a meeting in Malaysia in January 2000 fragment. On August 23, 2001, he entered the United States and began taking flying lessons. Why did such red flags go unnoticed? Zegart argues that after 1991, when the Soviet Union collapsed, there was no longer a perceived significant threat to U.S. national security. The CIA and other US intelligence agencies had focused on Cold War operations and thus, keeping track of a foreign terrorist was not seen as high priority. "The case of Khalid al-Mihdhar provides a chilling example of the subtle yet powerful effects of organization—that is, the routines, structures, and cultures that critically influence what government agencies do and how well they do it" (2005:78). Not only did the attacks on 9/11 change the direction and focus of U.S. national security, but it also changed the focus and direction of the FBI, CIA, and many other organizations and institutions.

This can also be seen in Frontline's *The Interrogator* (Smith, 2011). Frontline is an investigative television program as part of the PBS network. In this interview, Frontline correspondent, Martin Smith, discusses 9/11 investigations with Ali Soufan, who was one of the very few Arabic-speaking FBI agents working on Al-Qaeda. Ali Soufan, worked on various high-profile terrorism cases, including cases leading up to 9/11 (Soufan, 2013.). Soufan began his investigations with the October 12, 2000, USS *Cole* bombing attacks. Two suicide bombers attacked a U.S. Navy ship stationed in Yemen (9/11 memorial, nd). During his interrogations with a member of the group who carried out the USS *Cole* bombing and Al-Qaeda operative, Fahd al Quso, Soufan was able to uncover a significant amount of information about Al-Qaeda. However, he ran into a problem agents refer to as "the wall." FBI agents working on criminal investigations were banned from accessing various types of CIA intelligence. As he continued to uncover more information, he sent more and more requests to the CIA to get access to information. In July of 2001, his last request was sent. Soufan was doing work in Yemen when he watched the attacks that took place in New York on 9/11. He was ordered to stay there and discuss what he knew about Quso (a member of the group who carried out the USS *Cole* bombing and Al-Qaeda operative). When he arrived at the US Embassy in Yemen, he received an envelope with the information, which he had requested for months. When asked what would have happened if that information was shared, Soufan replied, "Oh, my God. This is a huge if. This is a huge if. I think the world would be very different today. I'm convinced" (Smith, 2011).

There is no guarantee that if "the wall" did not prohibit information sharing amongst the FBI and CIA that 9/11 would not have happened. However, organizational roadblocks like "the wall" and the development of individual cases within the FBI, created an obstacle within the intelligence community for information sharing that prevented pieces of a larger puzzle from being connected.

The unprecedented attacks that took place on September 11, 2001, shifted the attention and direction of focus in national security for law enforcement, intelligence, and government officials at the national, state, and municipal level. Shortly after 9/11 President George W. Bush, by congressional legislation created the 9/11 Commission in 2002 (9/11 Commission, 2004). The commission released a complete account of events encompassing the attacks that happened on 9/11, which include preparedness for response to attacks and recommendations for future incidents. The commission report recognized the new terrorist threat posed to U.S. national security and recommended implementing changes by creating a joint effort among multiple levels of government and law enforcement. More specifically some of the recommendations included unifying counterterrorism intelligence and operations with a National Counterterrorism Center, intelligence communities operating under a national intelligence director, reforming the FBI with a strong security workforce and recruiting specialist for security and intelligence, and changing how information is shared. The report found many institutional breaches and failures and while a public statement on the report states that, "if, God forbid, there is another attack, we must be ready to respond. We must educate the public, train and equip our first responders, and anticipate countless scenarios" (New York Times, 2004). There is nothing in the report about the role of the community/public. Legislation passed after 9/11, as recommended by the report made changes in the organization of government to address the new domestic security landscape most well-known was the Patriot Act.

The Patriot Act was passed by Congress shortly after 9/11 to strengthen tools used to fight terrorism (26 October 2001). The passing of the act sparked much controversy and debate because some of the provisions seem to invade some civil liberties and rights. Some of the controversy comes from the issue of surveillance and privacy. Title II of the act called for "Enhanced Surveillance Procedures" in which the powers of the government to investigate

terrorism-related activities were expanded. For example, "Section 213 under title II of the act, "[a]llows 'Sneak and peek' search warrants, which let authorities search a home or business without immediately notifying the target of a probe" (Abramson and Godoy 2006). The controversy stems from a breach in American citizen's civil liberties and rights. The first amendment of the United States constitution enumerates that "Congress shall make no law" (LII, 2010) that would counterbalance the guaranteed freedoms of the right to petition, speech, assembly, religion, and expression, as outlined in the first amendment. In a Gallup poll which asked, "[s]hould the Government take all steps necessary to prevent additional acts of terrorism in the U.S. even if it means your basic civil liberties would be violated?" in 2002, 47% of respondents answered yes, even if civil liberties are violated. In 2003, that number went down to 29% (Abramson and Godoy 2006). With time American citizens are realizing that when national security is threatened the choice between wanting to be free while also wanting to be secure and protected are challenge. The patriot act is only one example of the many changes that occurred following 9/11.

The 2002 Department of Homeland Security Act sought to protect the United States from a variety of threats including, terrorism, cybersecurity, border protection, and disaster resilience. The act also created first the office of Homeland Security then the U.S. Department of Homeland Security. The new department led to a reorganization in which the Secret Service (previously under treasury department), Federal Emergency Management Agency, Transportation Security Administration, and U.S. Coast Guard (previously under the Department of Defense) were put together to better coordinate national responses to attacks and natural disasters. All these organizations aid in protecting the homeland from various threats. On October 7, 2011, the Department of Homeland Security released for the first time its National Preparedness Goal. The goal is a nationwide vision to accomplish preparedness for five mission areas which include mitigation,

recovery, prevention, protection and response to disasters whether they be natural or man-made. Craig Fugate, FEMA Administrator (2011), said, "[a]s we work to build a more prepared nation, we must work with the entire community – the public and private sectors, faith-based and non-profit organizations, and most importantly the public" (DHS, 2011a). This national preparedness goal helps to define the core means necessary in order to prepare for the threats posing the greatest risk to the security of the nation.

The 2004 Intelligence Reform and Terrorism Prevention Act took reorganization and response practices a step further. The act was meant to enhance, "the intelligence and counterterrorism capabilities of the United States, including by appropriate implementation of the recommendations in the Report of the National Commission on Terrorist Attacks Upon the United States, often called the 9/11 commission" (George W. Bush, 2004). The act had eight sections highlighting the breadth of its focus from reforming the intelligence community, FBI, security clearances, transportation security, border protection/immigration/visa matters, terrorism prevention, implementation of 9/11 commission recommendations, and other matters. The act established a Director of Intelligence, and created National Intelligence Centers, a National Counter-Proliferation Center, and a National Counterterrorism Center. One of the principal changes that came with the act was the Director of National Intelligence (DNI) position with great authority over the intelligence budget, intelligence community staff, and authority over counter proliferation and counterterrorism centers.

While most of the act provides recommendations regarding the federal and state level there also are some recommendations for local level government. Under Title VII, Subtitle C of the act mentions national preparedness. Section 7303 of the act discusses enhancing communications and capabilities for public safety. In this section, the Homeland Security Secretary is tasked with

designing a program to build up public safety on all levels of government. Take for instance, Sub-Section I under Section 7303: the purpose is to "provide technical assistance to state and local public safety agencies regarding planning, acquisition strategies, interoperability architectures, training, and other functions necessary to achieve public safety communications interoperability" (U.S. Congress, 135).

There are 99 instances in which the *Intelligence Reform and Terrorism Prevention Act* mentions the word "community" and while referring to intelligence, financial, or international communities it does not mention the American public/community and their role in countering terrorism. It talks more about governments dissemination public safety communications. Overall the act was established to provide for better communication and coordination within the intelligence communities which was lacking before 9/11

Security before 9/11 consist of individual cases along with cold war dominated operations. The puzzle pieces foreign terrorist left behind were not being traced and put together to see a bigger picture. The 9/11 attacks ushered in new government structures and policies to add to the terrorist toolbox in which the U.S. could use in order to counter terrorism. These tools helped to establish new government structures as well. Specifically, the implementation of the *Patriot Act*, the creation of the Department of Homeland Security, and the 2004 *Intelligence Reform and Terrorism Prevention Act*. More recently, with the 7/7 attacks that took place in London 2005, community approaches to counter terrorism were brought to the light as being a tool to use. These community approaches are being implemented in the United States. However, there are many challenges and things to consider with these approaches and their effectiveness. Prior to analyzing some of these challenges a glance at what domestic terrorism looks like in the Unites States is helpful.

The Scope of Domestic Terrorism in the United States

Domestic terrorism involves terrorist acts and attacks that happen in the United States. According to the Federal Bureau of Investigation (FBI), domestic terrorism involves three characteristics: 1) the act is dangerous to the lives of humans and breaches state or federal laws; 2) the act is on U.S. soil; and 3) the act appears to use intimidation to coerce citizens, influence policy, or impact government by means of mass destruction, kidnapping, or assassination (Haerens, 2015:30). The differing types of domestic terrorism range from right/left-wing, separatist and hate groups to eco/animal rights, single issue, and ideological terrorism on the home front. One of the biggest challenges on U.S. soil is what senior researcher at the Danish Institute for International Studies Manni Crone and author Martin Harrow have recently been credited for the term "homegrown" following the London July 7, 2005, attacks (Zekulin, 2016). Prior to discussing this newly categorized threat it is important to look at a few well-documented examples of domestic terrorism in the United States, namely, the Oklahoma City bombing, the Sikh temple shooting, and the Boston Marathon bombing.

On the 19th of April in 1995, a truck was parked outside the Alfred P. Murrah Federal Building in Oklahoma City (Jenkins, 2016). The truck had a homemade bomb inside and when detonated 500 people were injured, killing 168 people which included 19 children (2016). Shortly after the attack had taken place, two men, Timothy McVeigh and accomplice Terry Nichols, were pulled over by an Oklahoma police officer because of a license plate violation. When it was discovered that McVeigh had an illegal concealed carry weapon he was arrested. Two days following the attack Nichols turned himself in. Nichols received a life sentence in prison and McVeigh was sentenced to the death penalty. The Oklahoma City bombing was, until 9/11, the deadliest domestic terrorist attack on U.S. soil.

Another example of domestic terrorism is the Boston Marathon bombing that took place in 2013. The Boston Marathon is an annual

race that initially took place on April 19 to commemorate the beginning of the Revolutionary War. The race is one of the most prestigious racing events (BAA). At 2:49 pm on April 15 in 2013, two bombs exploded near the marathon's final stretch (United States of America v. Dzhokhar Tsarnaev, 2013). Three people were killed in the explosions and more than 200 were injured. The two men who were later identified as the terrorists who planted the bombs were brothers, Tamerlan and Dzhokhar Tsarnaev.

The last example of a domestic terrorist attack is the Wisconsin Sikh temple shooting. On August 5, 2012, a gunman opened fire at a Sikh temple near Milwaukee killing six people and wounding three (Laris, et. al., 2012). The gunman was later identified as Wade Michael Page, an Army veteran and white supremacist. According to the Southern Poverty Law Center (SPLC), a civil rights network which monitors hate groups, "Page was a "frustrated neo-Nazi who had been the leader of a racist white-power band." He had been "part of the white power music scene since 2000" (Beirich 2012). Page's act of terrorism is what is classified as right-wing terrorism. Right wing terrorism refers to ideologies that stem from groups with such as anti-Muslimism, anti-government, anti-immigration, white supremacy, and militia groups.

The Oklahoma City bombing, the Boston marathon bombing, and the Sikh temple shooting provide examples of what domestic terrorism looks like in the United States. These acts are also smaller puzzle pieces that link to a bigger trend in domestic terrorism. Not only are there attacks happening on U.S. soil but the attacks are disproportionately coming from one type of terrorist group: namely right-wing terrorism.

Right-Wing Terrorism.

Right-wing terrorism or extremism is a growing threat in the United States. There is a common misconception that domestic terrorism originates internationally and then extremist travel to the United States and commit acts on U.S. soil. Following 9/11,

terrorism discourse in the United States has been focused on Al Qaeda and jihadism (A pillar of the Islamic faith meaning sacred "struggle" or "effort.") Islamic extremists have interpreted Jihad to mean waging a holy war (Martin 2016; G-9). However, according to a 2010 study conducted by the Institute for Homeland Security Solutions, while Al Qaeda and allied movements influenced 48 out of 86 attacks in the study, right wing groups (i.e. militia/anti-government and white supremacist) were to blame for 32 attacks, a considerable portion (Strom, et. al., 2010:7). Most domestic terrorist attacks are from American citizens who have a far right-wing agenda.

In addition, a study was carried out by the Anti-Defamation League in 2017 demonstrating the significant proportion of terrorist attacks that are attributable to right-wing groups during the 25 years prior to the study (ADL, 2017). In the 1950's "burning Kansas" and 1960's Ku Klux Klan are early examples of the history of right-wing terrorism in the United States. A majority of right-wing extremism falls under the umbrella of right-wing extremism but within two distinct spheres: anti-government and white supremacist. According to the study, 85% of terror incidents in the US from 1993 to 2017 were attributable to members of one of the two spheres. "Moreover, the number of acts attributed to each sphere is almost identical: 64 terror incidents are related to white supremacists, while 63 are related to anti-government extremists" (2017:3). The two spheres although representing two distinct categories fall under the same umbrella of right-wing terrorism.

CNN intelligence analyst, Peter Bergen, and New American Foundation program director, Jennifer Rowland write about this in their "Growing Threat of Extreme Right-Wing Violence" (2013) article featured on CNN. The authors call on politicians to shift their focus from Al Qaeda and allied threats to the rising threat that right-wing terrorism poses. According to Berg and Rowland, "of the 54 non-jihadist terrorists indicted between 2010 and 2012, 47 were right-wing extremists" and "since 9/11, at least 29 people

living in the United States have been killed by right-wing extremists, while 17 have been killed by jihadist extremists" (Bergen and Rowland, 2013). The focus of international terrorist organizations or domestic threats motivated by those ideologies, have deterred Americans from seeing other threats in the United States. Right-wing terrorism is on the rise and more awareness of this threat is needed.

While there has been notice of increasing terrorism which is coming from the right there has also been notice of another type of terrorism. Domestic terrorism has shifted from a conventional model where groups of people were acting as one unit, rather to individuals acting alone. This phenomenon is what is known as homegrown terrorism.

Homegrown Terrorism

A newly categorized type of domestic terrorism is homegrown terrorism. According to a study done by the Institute for Homeland Security Solutions, "more than 40% (35 cases) of terrorist plots from 1999 to 2009 were planned or carried out by single individuals, or 'lone wolves' (individuals not directly under the command structure of a group or movement but who sympathize with a particular cause)" (Strom, et. al., 2010:8). By comparison between small or large groups, individuals acting alone were also more successful in executing attacks. A homegrown violent extremist (HVE) is someone who lives in the United States and uses terrorist activity to further an ideology (Halpern 2013). This individual also acts alone so detecting an HVE before an act is difficult.

A chilling example of a "lone wolf" can be seen in the 2016 Orlando nightclub shooting. The incident took place on the 12th of June, in 2016. A gunman opened fire at Pulse, a gay nightclub, and one of Orlando's biggest nightclubs (BBC News, 2016b). More than 300 people were in the club that night. At this time, the gunman claimed title to making this the worst mass shooting, killing at least 49 and injuring dozens (BBC, 2016b). The gunman was later

identified as Omar Mateen. Mateen was a New York born citizen to Afghan parents (BBC, 2016a). About a half an hour following the initial open fire, Mateen contacted the Orlando Police dispatch center. He told the dispatcher, "I pledge my allegiance to Baghdadi on behalf of the Islamic State," (Ross, 2016).

What the Oklahoma City bombing, the Sikh temple shooting, the Boston Marathon bombing, and the Orlando nightclub shooting all have in common is that they are acts of what Crone and Harrow call "homegrown terrorism." According to the Federal Bureau of Investigation, a homegrown violent extremist (HVE) is anyone who has lived in the United States and uses terrorist activity to further an ideology. This individual also acts alone (Halpern, 2013). Because these individuals act alone detecting them before they act is very difficult.

Peter Bergen, CNN national security analyst, talks about homegrown terror in his 2016 CNN article, "The Real Terror Threat in America is Homegrown". Bergen refers to the Orlando nightclub shooting as a grim pattern of American citizens operating as lone individual in carrying out attacks in the United States. He mentions that even though the perpetrator of the attack, Omar Mateen, pledged his allegiance to ISIS during the act, he was still an American born citizen who had no formal training from ISIS. This homegrown threat presents a problem for law enforcement because these individuals act alone leaving no trace of communication with other terrorist organizations to be intercepted by intelligence analyst. They also do not conspire and have meeting with other people so FBI monitoring is also difficult.

This newly categorized threat, as outlined above, is on the rise and difficult to detect. In response to home grown terrorism the United States government has produced two strategies that outline this threat and provide various implementations to counter it. The Department of Homeland's Security's (2016) and the White House's (2011) strategies discuss using community approaches to countering violent extremism. While some have noted that community

approaches may be an effective tool to fight violent extremism, specifically homegrown violent extremism, there can be some challenges (Schanzer, David, et al, 2016, Cherney et. al., 2015, Briggs, 2010, Haerens, 138).

Preventing Domestic Terrorism through Community Partnerships

The debate over how to effectively fight domestic terrorism is ongoing. Domestic terrorists are continuously acquiring new ways to instill fear. Analyzing these trends will help to keep up with the evolving tactics in order to effectively counter domestic terrorism. Because of the threat homegrown terrorism and violent extremism present, the federal government has intimated that protecting American communities means working with American communities. According to the *2011 Empowering Local Partners to Prevent Violent Extremism in the United States* strategy, “[c]ommunication and meaningful engagement with the American public is an essential part of the Federal Government’s work” (DHS, 2011b: 5). Outlined in the strategy is a community-based approach as essential to counterterrorism efforts.

Former Secretary of Homeland Security, Janet Napolitano, talks about law enforcement and local communities as being an essential part of counterterrorism. In her viewpoint, she acknowledges that homegrown terrorism presents a new threat and challenge to the homeland. Fighting this threat includes providing law enforcement the information and resources necessary, which includes information sharing, grants, and public awareness. Referring to the nationwide “see something say something campaign”, which emphasizes the importance of suspicious activity reporting she says, “We see this as a way both to empower the Americans to take part in our nation’s security and to build important relationships between citizens and SLTT law enforcement in order to ensure local authorities have the information they need to stop terrorist attacks” (Haerens 2015:138). Well-informed and attentive citizens can help to fight against attacks on the home front.

Security expert Rachel Briggs also discusses community engagement in her 2010 journal article, "Community Engagement for Counterterrorism: Lessons from the United Kingdom." According to Briggs because homegrown individuals are integrated members of society community members being engaged and informative is also an essential counterterrorism strategy. Communities can act as an early warning sign for suspicious and unusual behavior reporting system to local authorities. According to Briggs, community-based efforts in counterterrorism is not a new idea. Moreover, following the London 7/7 attacks, a community-based approach to counter homegrown individuals was brought back to the light. The first implementation of this approach was introduced in 2005 with the Preventing Extremism Together Taskforce (PET) (Briggs, 2010). Over the next five years progress has been made with a counterterrorism strategy provided by the government and increased funding. However, there is a struggle with practicalities and principles of non-state actor partnership in regard to counterterrorism and security. With a new government coalition to review the counterterrorism strategy, Briggs article offers three recommendations for community engagement and counterterrorism in the UK: 1) the government should take an all-or-nothing stance on partnership working 2) in order to increase community knowledge, local law enforcement should be working with the people other than projects and 3) the governments prevent strategy should shift focus to downstream de-radicalization and prevention work instead of working up with community development (2010). Briggs argues that while community engagement is now an enacted counterterrorism strategy in the UK, partnership should be "locked in". For communities to fully play a part in this long-term counterterrorism effort they need time to grow into the role.

While community engagement may provide benefits to counterterrorism there can be some challenges. University of Queensland professor, Adrian Cherney, and Jason Hartley discuss this in their 2015 journal article "Community Engagement to Tackle

Terrorism and Violent Extremism: Challenges, Tensions, and Pitfalls." According to the two, community engagement in the context of counterterrorism is important because disconnecting terrorist organizations from their campaigns, which aim to gain supporters, can potentially be an effective measure in fighting terrorism. There are counterterrorism efforts that involve community engagement and while there are a number of benefits with this approach, like the one previously mentioned, there are also disadvantages. According to the two there are three sources of tension: Overcoming distrust and generating trust, balancing intelligence gathering, community engagement, and trust building, and choosing partners and distinguishing between friend and foe.

Specifically, with overcoming trust and generating trust, for community engagement to be an effective tool in counterterrorism there needs to be a level of trust. Because police are the salient visible representation of the state they deal with levels of trust or distrust. For trust to be mutual people need to believe that police and law enforcement have the people's best interest at heart. Trust can be lost especially when people see police or law enforcement acting contrary to authoritative statements. For example, counterterrorism efforts are not directed at Muslim communities. "It has been documented that the police use of stop and search powers against Muslims, blanket surveillance of Muslim communities, police raids and searches of Muslim homes, the cancelling of passports preventing Muslims from travelling overseas, and informal questioning of Muslims by police have generated a sense among Muslims that they are under siege" (Cherney et. al., 2015). This has been intensified by the war on terror environment with all of its surrounding political and social narratives. Generating trust in this environment requires law enforcement to show neutrality in engagement work. But trust can be lost.

Because of the threat violent extremism presents, establishing and growing trust is a core principle in community-based

counterterrorism efforts. Specifically, Muslim communities and police. Working together and building trust is essential.

David Schanzer, Charles Kurzman, Jessica Toliver in *The Challenge and Promise of Using Community Policing Strategies to Prevent Violent Extremism* report conduct research to assess how work is being done by policing agencies with communities and Muslim Americans to increase public safety for countering violent extremism. Following the attacks that took place on 9/11, community-policing approaches became known as a possible counterterrorism strategy.

The first aspect of the project included a survey of local and state law enforcement agencies to better understand their community policing practices. The second aspect included telephone interviews with county law enforcement agencies. The final aspect of the research included visiting local law enforcement jurisdictions. The team's nation-wide survey found that a majority of policing agencies are utilizing some form of engagement/outreach in terms of addressing violent extremism. However, the outreach and community engagement are supported or not deeply ingrained. For example, when asked "which community- oriented strategies the agencies used to counter violent extremism", out of all the respondents more than three quarters noted that their agency was using at least one of the outreach/community strategies in relation to countering violent extremism (Schanzer, et al, 2016). When compared to the results from two 2003 and 2007 U.S. Department of Justice surveys, the use of community policing practices over the past decade has grown.

However, policing agencies encounter some obstacles when reaching out to community partners for preventing violent extremism. One such difficulty, outlined in the report, is that for some communities the efforts and partnership are being applied to violent extremism by Muslims while not addressing other forms of violent extremism. There are internal obstacles that policing agencies encounter as well. Despite these obstacles in community policing strategies for countering violent extremism, this research

shows that there are positive relationships with numerous police agencies and the Muslim American communities in which they serve. Based on some conversations with community members as well as police there is a suggested set of principles to be followed which lay groundwork for effective relationships between police and communities. This research however did not scientifically test for effectiveness of these concepts, but because police departments mentioning frequently with comments from community interviews, there is confidence in labeling these concepts as “promising practices” (2016). These practices include: committed police leaders and a community open to engagement, policing strategies that involve the entire community rather than just Muslim Americans, engagement and outreach programs should be separated from criminal investigation and intelligence gathering, policing agencies hiring and recruiting a workforce that reflects community composition, effective engagement/outreach requires a different types of training, police should conduct a range of activities for engagement, and police working with communities in order to develop intervention models that are non-criminal. While there may be some obstacles in developing relationships with the community to counter violent extremism, with community policing principles these obstacles can be overcome. These principles can enhance public safety, progress community goals, and help to counter extremist violence.

The examples of homegrown terrorism attacks described above and the importance of community engagement to thwart such attacks are topics focused on in the literature. It is clear that the US Government now recognizes, in principle, the importance of community integration based on the DHS and White House goals in the strategy for fighting terrorism, perhaps in large part due to the efforts of terrorism experts and scholars such as Briggs (2010) and Strom (2010). This focus leads to the focus of this paper: What efforts are in place and how effective is community engagement in US and local government counterterrorism efforts? This is the

question that I sought to answer through field research in Denver and the Rocky Mountain front range area that includes parts of Wyoming.

Preliminary evidence suggests that cooperation between community groups and law enforcement agencies is not a natural fit and therefore, even though the intention of these counterterrorism agencies is to work effectively with communities, in actuality cooperation is somewhat thin. It is my aspiration that the outcome of my research will point the way to specific improvements that can be made in law enforcement community engagement strategies so that this essential piece of the national counterterrorism strategy will have the attention and support that it deserves. To see what efforts are in place and how effective community engagement in US and local government counterterrorism efforts are this project conducted a case study of local community partnerships to assess their development and use in the Rocky Mountain area. This case study included in addition to the review of literature above, semi-structured interviews, participation in a community public safety course, and a terrorism awareness survey was made and conducted.¹

Case Study Methods

As established in the literature review section, due to the embedded nature of homegrown terrorism, experts have suggested that links between law enforcement and the community are essential to counter-efforts. There is a need, therefore, for a critical assessment of the current state of community/law enforcement partnerships on countering homegrown violent extremism. If these partnerships are not effective, evidence up to this point suggests that counter-terrorism efforts will not be as effective as they otherwise could be. Thus, on the case study in this paper is an effort to field-test the effectiveness of these partnerships in a specific area in the United States, namely the Colorado/Wyoming

¹ The terrorism awareness survey was conducted in Denver, CO, and Cheyenne, WY, to see if people were involved in or aware of any

front-range area. To generate data to make an assessment on the effectiveness of these partnerships, I will seek to answer these two questions: 1) what do counter-terrorism community partnerships look like? and 2) how effective are they? Research methods employed to answer these questions included interviews, participant observation, and quantitative surveys. Twenty-four semi-structured interviews were conducted with government officials and non-government organizations in Denver, Cheyenne, and the Front Range (see Appendix A).

This research is what Robert Yin termed as a case study. According to Yin, case studies give one the opportunity to dive into a specific case in order to examine and explain challenges with multiple cases (Yin, 2003:3).

First, this study collected qualitative data through semi-structured interviews and a survey. Interviews were arranged through appointments at a time that was convenient with the interviewee. The terrorism awareness survey was conducted in Denver, CO and Cheyenne, WY and was designed to see if community members were aware of/engaged in any community partnerships that help to fight/respond to terrorism. Some research took place at the Counterterrorism Education Learning Lab, located at 99 West 12th Avenue, Denver, Colorado, 80204 as well as other public locations in Denver, Colorado and other municipal locations in cities along the Front Range such as Ft. Collins and Cheyenne, WY. All interviews took place at the time and place of the participant's choosing.

Sample and Materials

This study's participants included government officials, non-government officials, and local community members. Altogether there were 50 participants. Twenty-four semi-structured interviews were conducted with government officials and non-government organizations in Denver, Cheyenne, and the Front Range. Twenty-six participants were local community members, chosen at random, to

participate in a survey. Recruitment was done in different ways for different people. For government and non-government officials, contact was made with the organization and participant names were nominated by an engagement number, type (government or non-government), and location. The local community members were selected at random, approached in person and asked if they were willing to participate.²

Interviews were also employed in the research process. Interviewees answered questions as a part of a semi-structured interview following prompts taken from interview guides. Participants were told about the consent process at the initial point of contact for recruitment, and provided with a physical copy of the informed consent statement during the time of the interview or before the interview commenced. Compensation and incentives were not provided. Once arrived at participants choice of interview location introductions were made. Following introductions, permission to record and confidentiality of names and sensitive information for the production of this paper were discussed.

Interview guides were used to assist in conducting the interview, according to the type of participant. The various groups included: cooperating law enforcement, local government, and Counterterrorism Education Learning Lab partners, and Department of Homeland Security (DHS). The interview guides had four sections: Write down but do not ask, general questions to set the tone, main questions, and conclusion. The write down but do not ask section asked for the sex and political orientation of the respondent. The general questions to set the tone section asked questions like, "tell me about yourself", "What do you do?", "What are your responsibilities in this position?", and "How did you get to where you are today?". The main questions section asked, "Does your institution have a definition of terrorism?", "How is it working with this institution?", "What do you think about a community-based

² The equipment used on the participants were a pen and notepad along with, upon affirmative response, a recorder

organization that prevents terrorism through engagement, empowerment, and education? Is it good or bad?", "Have you heard of CELL, or no of any organizations like it?". Finally, the conclusion section asked, "Is there anything else you want to tell me?"

A terrorism awareness survey was also included. The terrorism awareness survey was conducted in Denver, CO and Cheyenne, WY and was designed to see if community members were aware of/engaged in any community partnerships that help to fight/respond to terrorism. The survey had 7 questions. The first question was opened ended and questioned what the participant first thought of when thinking about terrorism. The second question asked if terrorism was something the participant was worried about. Yes and no were the only options provided. The third question provided a scale of 1-5, one being the least and five being the most, which asked if the participant felt threatened by terrorism. The fourth question asked if something were to happen at (major local event), would the respondent know enough to be able to respond or could have helped prevent the act of terrorism in the first place. A yes or no option was provided. The fifth question asked if the responded thought that community organizations could play a role in preparing one to respond/prevent. A yes or no option was provided. The sixth question asked the responded if they were ever engaged in or aware of any community partnerships/efforts to prevent/respond to terrorism. A yes or no option was also given. If the answer was yes, there was a follow up question which asked the respondent to name that community partnership/organization. Finally, the seventh question asked the respondent their opinion of the community partnerships/organization and how effective they are.

The sample, material, and procedures in this study were used to see what efforts are in place and how effective community engagement in US and local government counterterrorism efforts are. In conducting research, three overall themes were present and discussed in more detail following this section.

Findings

Throughout the interviews, there were four themes that arose from the conversations, taken together create a picture that sheds some light on the state of community partnerships and their effectiveness. These themes are civil liberties, rights, and invasion of privacy; trust; information sharing; and lack of community awareness. These themes are discussed here below:

Discussion of Major Themes

1. Civil Liberties And Rights: Invasion Of Privacy

Many participants in the research gave responses reflecting negative views on how the American public views the work of counterterrorism efforts as a means to spy on and infringe the rights of the average citizen than as a means for national security. Out of 10 interviews, four interviewees mentioned this issue. There were three responses that reflect negative views that Americans have for counterterrorism work. Two respondents also mentioned that people think of their work as a spying technique. One respondent said, "and then you got the people that have that mindset that we are we do spy on people you know we don't and that's another challenge we're faced with constantly" (10). Moreover, two respondents mentioned civil liberties and rights as a core principle in their counterterrorism work. One respondent said, "and I would like to stress like our state and any state every state ... takes so seriously uh privacy and civil rights, it's like a cornerstone for everything we all do because it something we don't want people I don't want homeland security spying on Americans for whatever reason I mean I definitely want the appropriate actions to be taken place, we have to be very careful" (9). In addition to protection of civil rights and liberties, the respondent said, "very careful about throwing the term terrorist around" (9). Given the tension outlined above where the law enforcement is leading community engagement, what does this imply, then, when efforts are made to co-opt community members into

the same spirit of investigation? Will this tension be diffused? Or will it be exacerbated? Something that was implemented shortly after 9/11 was the Transportation Security Administration's (TSA) detailed security checkpoints at airports around the country. One TSA official interviewed noted that when members of the general public are subjected to screening, "most people just look at it as an invasion of their privacy" (5). The official also added, "They totally forget why we do that" (5). This is a typical representation of the friction created by counter-terrorism efforts with the public, or with the "community."

The threat HVE poses has led to the formation of programs like the 'see something say something' campaign or videos like "run, hide, fight." These videos and campaigns encourage and show individuals how to be civilian agents of law enforcement and essentially watch other people and report suspicious behavior. This, yet again, can be seen as an infringement upon an individual's civil liberties and rights. Senior American Civil Liberties Union (ACLU) staff attorney, Alex Abdo talks about this in his "You may Have 'Nothing to Hide' but you Still Have Something to Fear" 2013 article. According to Abdo, the argument behind having 'nothing to hide', in reference to the 'see something say something campaign', implies that privacy is a concept only applicable to criminals. He adds, "even if you think you have nothing to hide, you may indeed have something to fear" (Abdo, 2013). There is also the possibility to fear society. Living amongst friends, family, and neighbors who are constantly watching each other for suspicious activity can cause long term social institutionalism of fear. This effect can cause what was previously an open society into a fearful cautious one.

2. The Issue of Trust

Another theme that was present throughout the responses was trust: trust not having to do with the handling of classified information, but trust as in being able to trust someone and work together on something with shared goals. For community engagement

to be an effective counterterrorism tool, trust must be established between community members and law enforcement partners. For the community to be able to report suspicious behavior and act as a valuable partner in counterterrorism efforts they need to do so as a trusted partner from their local authorities. Local authorities also need the communities that they serve to be aware and capable of trust so a mutual relationship can be established. The relationship and level of trust goes both ways.

All relationships that involve multiple parties towards the effort are important. Moreover, the responses in this section mostly reflect trust as a negative instance and a barrier in information sharing and counterterrorism work if lost. Some of the comments reflect a neutral tone about building trust. For instance, one official noted, "so that's the hard part ... how do you gain that trust, how do you build that trust?" (4). The official also added, "I think you have to be careful about who you put in charge of those things," (4) referring to information dissemination and awareness building that empowers community members to join in the counterterrorism effort. There was a particular partnership pilot between the law enforcement agency that this official represented and a community organization to disseminate information that was related to improving the security of the community. For some reason, the information disseminated by the community organization was not of the quality and thorough nature that was expected from the partnering and supporting agency. This became a reason, in this official's mind, not to partner with such organizations in the future. In an instance like this, because trust was lost, ultimately counterterrorism efforts may be hampered.

The importance of building trust, however, is still crucial, whether federal or state agencies are leery of working with community organizations or not. One security official noted that, "in fact we have to work with the communities and have their trust because the communities are usually the first and any whether it be the Muslim community any community they're the first one who notice

indicators and they're usually the first ones to alert authorities and without that without trust or mutual understanding that's never going to happen" (9). The community, however, is often leery of lending its trust to a federal or state law enforcement agency to begin with. One Homeland Security official made note of the challenge counterterrorism efforts are when the trust of the community is not won over. This person mentioned, "I can go to Big Horn County, say I'm with DHS, I need your information... They can tell me to ... get out of here. You know county, they're only going to give it to you if they trust you" (9).

Even between government agencies at state and federal levels, trust is a real issue. Another official noted, "one of the biggest challenges is ... we just gathered all this information we didn't put anything out and so building the trust of other agencies throughout the state ... was a challenge and it still is in some aspects" (10). It would go without saying then, that community partnerships, where expectations are not always in sync, would be an even greater challenge with respect to building trust, from both sides. Another official mentioned that, "building that relationship where they're willing to participate which is not going to always happen, it's not always the case. It's definitely like a central challenge" (9). Risks that one agency might take in working with a community organization could lead to a breach of trust not only between the organization and the agency, but between that agency and other agencies. One other official mentioned that in collaborating with others, "if you break that trust you're probably in hot water from a federal standpoint but more importantly you will then probably, or this agency would probably lose its ability and clearance - I wouldn't get information shared" (3).

Information Sharing

Another theme that was prominent in discussions of community partnerships among research participants was information sharing. Information sharing is an important topic in this study because

information sharing was not always happening to the degree that it could be pre-9/11. With community engagement used as a tool for countering violent extremism, law enforcement officials admit that an engaged public and citizenry are usually the first to see something suspicious and can then share that information with authorities. Information sharing is essential in this process. One official noted, "one of the great things that we do now that we didn't do before 9/11 is, and this starts down at the local law enforcement level all the way up through DHS and so forth, we share as much information as we can" (5). Another respondent mentioned, "we have a meeting once a month and we'll learn from probably seven, eight people to probably thirty people. Yeah, we had to change rooms we had so many people and it's a very good thing because it shows that every agency is willing to lay what they have out on the table for everyone else to share. Not always been the case, especially before 9/11. We call it stove-piping where people would hoard their information, still happens a lot everywhere" (9).

Information sharing has taken on a deeper dimension, with different agencies playing different roles in looking at particular bits of information and sharing them with other agencies. This official also noted, "we report information kind of that happens in the state uh also we uh analyze information uh from the national intelligence community into more finished products and then make that available to the state so kind of the information flow goes both ways" (9). Information sharing has become a two-way street that goes down multiple avenues. One official mentioned this saying, "we get bulletins we get email I mean we get all kinds of different information from all the different organizations that are in the same fight and like I said that goes to some of the other countries we get information from some of them and we share their information with them and back and forth" (5). That respondent also stated, "we all share information we all have one form or another of uh tasking that you know we do together to prevent you know any kind of terrorism activities so" (5).

Information sharing, then, is on the rise and much improved post-9/11 between different federal and state law enforcement agencies. This has been facilitated by the creation of fusion centers like the Colorado Information and Analysis Center (CIAC) and the Wyoming Information and Analysis Team (WIAT), which were both subjects of research. For example, existing organizations may be partnered with law enforcement agencies to disseminate information. One such program is the "safe 2 tell" program. As Wyoming DHS officials mentioned, this program recently was introduced into schools in Wyoming where students can download an app in which they can send anonymous information and tips related to suspicious activity or behavior. That information would then be sent to a fusion center (threat-related information gathering/analysis center where information is shared between federal, state, local, and tribal partners), like that of CIAC or WIAT, and would be properly disseminated to the right channels. Using programs that are already organized and running could help to disseminate information.

Has the same improvement been happening in communication and information sharing between community members and law enforcement agencies?

Lack of Community Awareness

For the community to play a role in countering violent extremism and more specifically, homegrown violent extremism, they must be aware and engaged. If someone is aware of a threat and sees something unusual or suspicious then they can report that information and may have helped play a role in countering homegrown violent extremism. Most of the response of the community counter-terrorism awareness survey reflect that many members of the American public are unaware of counterterrorism efforts and what role they can play in advancing those efforts. One respondent mentioned this saying, "because the majority of U.S. citizens are in their own little world and they just ignore what's going on in

the world" (5). This person also added that the, "majority of Americans do not follow real close what goes on in the world" (5). However, another respondent says, "most citizens actually probably understand that terrorism is an issue" (9).

To get a better understanding of how aware the community is when it comes to community engagement for countering homegrown violent extremism a terrorism awareness survey was conducted. The survey was conducted in Denver, Colorado and Cheyenne, Wyoming. There were 26 completed surveys. When asked, "Have you ever engaged in or are aware of any community partnerships/efforts to prevent/respond to terrorism", 73% of the respondents were unaware. Another respondent added, "I think really and truly when we talk about how do we make things happen how do we get better at this it's about individuals being aware of what to look for" (3). The line of communication between local law enforcement and the community is thin. In an interview with two police officers, both had expressed receiving terrorism related training from a government agency and not working with community organizations in disseminating that information.

When asked "[i]f something were to happen at (major local event), do you feel you know enough to be able to respond or could have helped prevent the act of terrorism in the first place?" 53% of respondents felt they don't know enough to respond to the act. When asked if terrorism was something the respondent is worried about, 73% of respondents said yes. Finally, when asked "do you think community organizations can play a role in preparing you to respond/prevent?" 88% of respondents said yes.

There are organizations that help to increase community awareness about terrorism. One such organization is Counterterrorism Education Learning Lab (CELL). Established in 2008, CELL is a foundation that "is dedicated to preventing terrorism through education, empowerment and engagement" (CELL, 2012). The institution provides training, a public speaker series, and a one-of-a-kind interactive terrorism exhibit. The CELL is a

perfect example of showing the inattentiveness in the public when it comes to terrorism. The organization's main goal is to educate the public. There would be no need of CELL if people already knew about terrorism and issues related.

The four major themes discussed above reflect the struggles in the overall effort to fight the threat that homegrown violent extremism presents. Community engagement is essential in fighting this threat but there are some challenges. Based on the responses, civil liberties and rights, trust, information sharing, and lack of community awareness are some of the major roadblocks in the fight against homegrown terrorism. The next question then is what needs to be done so these things do not stand in the way of advancing progress towards countering terrorism in the United States.

Analysis

Due to the embedded nature of homegrown terrorism, experts have suggested that links between law enforcement and the community are essential to counter-efforts (Schanzer, et al, 2016, Cherney et. al., 2015, Briggs, 2010, Haerens, 138). There is a need, therefore, for a critical assessment of the current state of community/law enforcement partnerships on countering homegrown violent extremism. If these partnerships are not effective, evidence up to this point suggests that counter-terrorism efforts will not be as effective as they otherwise could be. Thus, this section reports on the degree to which these community partnerships could or could not be happening.

Need for More Effective Domestic Terrorism Policy

Based on data generated from field interviews and evidence, previous responses and news surrounding the need for community-based approaches to fight terrorism, there is a need for better policy that will more effectively address the need to establish and develop effective partnerships between communities and law enforcement, and in doing so more effectively fight the true

terrorist threat. In today's media culture, there is a common misconception that domestic terrorism originates outside the U.S. and that American Muslims are self-radicalized and carry out attacks on the home front. This misconception has generated racially charged debate and polarization across the nation.

On 27 January 2017, just one week following President Trump's inauguration, legislation was signed that prohibited travel to the U.S. from anyone from seven predominantly Muslim countries for 90 days. This executive order has gained excessive coverage and created a degree of chaos among those agencies charged with upholding the decision and among populations targeted by the travel ban. Many of the news stories, articles, and even the polls used the phrase "Muslim ban" rather than executive order. While in a sense the executive order does ban some Muslims from entering the country for 90 days, the phrase "Muslim ban" suggests a complete and total ban from all Muslims indefinitely. On the 26th of June 2017, however, the United States Supreme Court allowed for some of the revisions of the executive order to be implemented. Now refugees from six predominantly Muslim countries (Syria, Libya, Sudan, Iran, Yemen and Somalia) are temporarily prohibited from entering the U.S. unless obtaining a, "credible claim of a bona fide relationship with a person or entity" within the United States (BBC News, 2017). In an address to Congress on 28 February 2017, President Trump stated that said since 9/11, a majority of people being convicted for terrorism-related cases in the United States came from countries outside of the United States (Lee, 2017). The rhetoric around the "Muslim ban" suggests that the biggest threat the United States faces is foreign individuals coming from outside the country committing domestic terrorist attacks. President Trump's statement came from data collected from the National Security Division of the Department of Justice. Based on this analysis, since 9/11, out of 580 convicted persons in terrorism-related cases, 380 were born outside of the United States (2017). However, what is interesting is that only 40 convictions out of the

580 were planned or executed *within* the jurisdiction of the United States. Most of the cases were for terrorist related activities overseas. What this data actually implies is that there may be more convictions of American-born terrorists carrying out terrorist activities overseas than foreign-born terrorists carrying out terrorist activities in the United States!

Contrary to what this data says, President Trump's stance enunciated by his executive order supported the perspective that the greatest threat facing the United States was foreign-born terrorists. This perspective in turn spun out government policy primarily focused on fighting a secondary threat while doing little to devote any kind of additional resources to counter the primary domestic threat. Based on findings from the Government Accountability Office, the facts show that, "of the 85 violent extremist incidents that resulted in death since Sept. 12, 2001, 73 percent (62) were committed by far-right-wing violent extremist groups, and 27 percent (23) by radical Islamist violent extremists" (2017). Far-right domestic terrorism and homegrown violent extremism are currently more of a threat to the United States than foreign-born terrorists. By focusing solely on the threat that international terrorism presents one misses the scope and threat that American citizen-led terrorism presents on the home front. Looking at the facts, as opposed to the rhetoric, it is clear that in order to fight domestic terrorism, relying merely on immigration policy reform will not accomplish an effective response to most domestic terrorist threats.

The recent incidents that took place in Charlottesville, Virginia, illustrate this. On Saturday, August 12th, white supremacists and other far right affiliates gathered to "Unite the Right" with a march and protest (Astor, et al, 2017). Violence broke out when a car plowed into a group of counter protestors. One person was killed and at least 34 were injured. The driver was later identified as American-born and raised 20-year-old James Alex

Fields, Jr. On August 14th, Jeff Sessions, Attorney General, labeled the attack an act of domestic terrorism.

The "FBI does not keep track of active hate groups" (Andone, 2017). The Southern Poverty Law Center, a private non-profit organization, is the only know resource for such information (2017). Had government resources been focused on identifying the domestic terrorist threat among hate groups, perhaps the FBI could have more effectively worked to counter the August 12th attack or prevent it from happening in the first place. They could have successfully raised awareness of the public, moreover, regarding the activities of such groups bringing members of the public into counter-terrorism fold. It is clear that the focus on building community partnerships is not what it should be as reflected in counter-terrorism policy as it currently stands.

Need for More Resources

Proper focus in policy reflects proper priorities in public funding. Along with the need to shift the weight of focus onto the proper sources of domestic terrorism in counter efforts, there is a need for more resources to support community-based approaches in fighting homegrown violent extremism. There are many resources involved in fighting domestic terrorism. A lot of these things cost money and take time. The Department of Homeland Security (DHS) offers many grants that help fund preparation, prevention, and responding to disasters. This includes terrorist attacks - for instance, Countering Violent Extremism grants (CVE grants). In 2015, Department of Homeland Security received 10 million dollars from Congress to award funding at the state and local level governments, non-profit organizations, and college universities to help local communities advance their efforts in regard to countering violent extremism (DHS, nd). Ten million dollars spread out over 50 states, 16 territories, and over 3000 counties in the United States is a minimal amount of money that is not able to support any kind of effective community programming. For fiscal

year 2017 DHS has allocated 365 million dollars just for their pre-disaster mitigation fund (DHS, 2016). A few weeks before the attacks that took place in Charlottesville, Virginia, Life After Hate, a group that helps to fight white supremacy and de-radicalize neo-Nazis, was revoked of their CVE grant by the Trump administration (Schulberg, 2017). Trump aide and national security analyst, Katharine Gorka, told George Selim, the DHS official in charge of the CVE program, that the way the Obama administration dealt with countering violent extremism was not something she agreed with (2017).

The day following Trump's election win, Gorka's husband Sebastian, also a Trump White House official, said, "I predict with absolute certitude, the jettisoning of concepts such as CVE (2017)." In January after Trump entered the White House, John Kelly, DHS secretary, wanted the CVE program to undergo a full review, even though the grant recipients had already been announced publicly. While underway, FBI and DHS warned via internal intelligence bulletin against white supremacist hate groups and the current threat they pose to the United States, which exceeds that of any other domestic terrorist group (2017). However, on June 23rd, there was a new list published by DHS of award recipients and the Life After Hate group was not on it. Muslim Public Affairs Council, an organization for American Muslim advocacy, that was promised a \$393,800 grant to establish community centers was also revoked of its funding (2017). After the new list was published, DHS told the group that they are prioritizing organizations which work with law enforcement.

A little less than two months after the de-funding of Life After Hate, James Fields traveled to a white supremacist rally and used his car as a weapon to ram counter protestors. What is already a miniscule amount of money to support community engagement coupled with the de-funding of community groups that focus on addressing the right-wing terrorist threat provides just one example that shows that the US Government's priority is not on building

effective community partnerships for counter terrorism efforts. The gap in CVE efforts to fight the domestic terrorist threat is coming from the far right. If 2 out of 4 goals on the DHS CVE strategy are centered on community engagement, resources dedicated to community engagement are grossly out of proportion to the place that community engagement occupies among the DHS' stated priorities in rhetoric surrounding its counterterrorism approach.

To maintain consistency with the DHS strategy for CVE, law enforcement and other government officials de facto require more training and more engagement with the communities in which they work in. This must be supported on both sides, not only on the law enforcement side, which is why the grants and support for non-government groups engaged in the counter-terrorism effort is so critical. The public needs to be engaged and working alongside law enforcement. This joint effort will require many resources, like awareness programs/campaigns and training, and also trust between the parties.

There also needs to be a certain level of attentiveness and engagement from the community. The terrorism awareness survey conducted in Denver and Cheyenne aimed to assess if the community was aware of or engaged in any organizations that respond to/prevent terrorism. When asked that question 73% of the respondents were unaware. Of the 27% who were aware, only 6 respondents could name any such organization. It is clear the community is not aware of any community-based efforts to prevent homegrown violent extremism. A community-based approach to fight domestic terrorism will not work if the community is not aware of the threat, if they are not trusting and being trusted, and if they're not partnering with law enforcement.

Conclusion

In order to fight the domestic threat that homegrown violent extremism presents in the United States, policy must accurately address the sources of HVE and funding must enable that policy to

be implemented. Thus, immigration policy is perhaps not the most important tool for countering domestic terrorism because the larger threat originates in the United States. Funding is going the opposite direction so more money must be allocated for training and other community engagement programs. As we have seen with recent events these acts are not going away. Altogether, there needs to be more focus on community partnerships and trust where it can be built, focusing on what can be done together, as opposed to what cannot be done together. As previously stated, community approaches will not work if local law enforcement are not partnering with the communities in which they serve. Communities also need to be aware of the threat and partnering with law enforcement in their communities. Terrorism is a real threat to the United States not only internationally but also domestically. A well informed, educated, and prepared public can help prevent attacks domestically. As the incredibly brave Malala Yousafzai once said, "with guns you can kill terrorist, with education you can kill terrorism".

Appendix A: List of Interviewees

(with distinguishable identifiers and names removed)

Interview date	Engagement
#	Interview
Type	
Location	Sex

5/16/17	1	NGO	Colorado	M
5/16/17	2	NGO	Denver	M
6/16/17	3	GOV	Cheyenne	M
6/16/17	4	GOV	Cheyenne	F
6/21/17	5	GOV	Colorado	M
7/7/17	6	NGO	Cheyenne	F
7/7/17	7	GOV	Cheyenne	M
7/7/17	8	GOV	Cheyenne	M
7/14/17	9	GOV	Cheyenne	M
7/14/17	10	GOV	Cheyenne	M
7/18/17	11	GOV	Colorado	F

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Research Topic: Cosmogenic nuclide dating of the Selenga River delta

Introduction

Background on Lake Baikal and the Selenga Delta

The Selenga river delta is located on the eastern shore of Lake Baikal, the world's largest freshwater lake (with a depth greater than 160 km) Invalid source specified., which sits in Siberia, just north of the border of Mongolia. The Selenga River is the main distributary feed of both the lake and delta. The delta is approximately 600 km² (Dong et al., 2016) and drains northward from a basin approximately 445,000 km² (Tsybikdorzhiev, Khodoeva, & Gonchikov, 2012). The modern delta lobe is an important coastal estuarine environment for the area and the only delta connected to Lake BaikalInvalid source specified.. The delta itself has many distinguishing, and naturally occurring characteristics that make it so interesting for study. The delta is partially the result of tectonic movement and lithospheric flexure, creating uplift around the delta, and creating a very large basin to reside in, making it a prime example for study of active continental rifting influencing an active deltaic systemInvalid source specified.. The delta, progrades and aggrades at the edge of the half graben shelf, filling the half graben with sediment and allowing the accumulation of materials to continue (Dong et al., 2016). It is this prominent channel dominated aggradation and progradation atop subsiding basement rock, that give it its unique bifurcated bird's foot design. At the end of the delta are long sandbars and spits that run almost entirely around the delta, with openings for the water and sediments still in transport, to go out to the lakeInvalid source specified..

The current literature reviewed understanding of the history of the modern Selenga River delta geomorphology is that during the Pleistocene, the significant repeating glaciation that occurred worldwide, greatly affected the area, and caused incredible amounts of loamy and sandy materials to be deposited across the plain in terrace features (different levels and zones of sedimentation), then during or near the Holocene, the glaciation ceased and the melt eroded and cut through the sedimentsInvalid source specified.. The terraces, which are sandy-loamy quartz rich sediments, are the result of this isostatic rebounding that the Siberian platform was accommodating for during the Pleistocene glaciation and increased erosionInvalid source specified.. This current understanding is not undisputed, nor does it give extensive understanding to the order of events that created the observed stratigraphy and geomorphology. The aim of this study is to use methods of surface exposure dating to constrain the stratigraphic and geomorphologic history of the region.

Background on Cosmogenic Nuclide Dating of Beryllium 10

Cosmogenic Nuclide dating is a method of exposure dating of in situ geomorphological processes and will be used to constrain the history of exposure of the deltaic terraces in the basin (Cockburn & Summerfield, 2004). Cosmogenic nuclide dating, of river terraces, especially those which we can see are stratigraphically distinct packages, allow us to understand the age and climate at the time of deposition (Repka, Anderson, & Finkel, 1997). Cosmogenic rays are the high energy subatomic particles that bombard the earth from all directions constantly (Dunai, 2010). The cosmogenic rays that are constantly interacting with the surface of the earth produce cosmogenic nuclides (Dunai, 2010). Nuclides are a specific type of atom with a distinct chemical structure, that has measurable amount of energy and exists for a measurable amount of time (Nuclide, Atomic Number, Mass Number, 2014). In order for a nuclide to be suitable for study of in situ geomorphological processes, it must

meet several criteria: known production rate, altitude, latitude, irradiation geometry and shielding (Lal, 1991).

When dating the sediments from the Selenga River delta basin, we will be using the nuclide Beryllium 10 that has a determined $t_{1/2} = 1.5$ Ma (Repka, Anderson, & Finkel, 1997). Though this has been disputed, as ^{10}Be does not have a universally adopted half-life yet (Dunai, 2010). The production of ^{10}Be in sediment is usually the result of a spallation reaction, or a reaction where a subatomic particle has interacted with the heavier nucleus of the oxygen or silicon atom and emitted fragments from the body (Dunai, 2010). But in rarer cases, can also be the result of alpha particles interacting with ^7Li or by thermal neutron capture in beryllium bearing minerals (Dunai, 2010). However, formation by the spallation reaction is the most common in situ production method, thus it is the quartz within the terrace profile samples that will be the focus of this research done on the Selenga River delta terrace sediments. Quartz is the prime mineral to study due to its lattice structure being primarily Si and O (Lal, 1991). When working with ^{10}Be another factor that is needed to consider, is that ^{10}Be is produced in the atmosphere, also by spallation reactions, on nitrogen and oxygen, a thousand times faster than within rock. The meteoric or "atmospheric" ^{10}Be precipitates and is absorbed by the surface materials (Lal, 1991). To use cosmogenic radionuclide analysis, it is a requirement that the meteoric ^{10}Be be removed from the sample of mechanically and chemically purified quartz. Using ^{10}Be has only been possible since the development of the accelerator mass spectrometer, thus after a purified quartz sample has been produced, it is analyzed by an AMS (Lal, 1991). After analysis, the data can be used to constrain absolute ages through a series of equations. The absolute ages of the terrace samples will allow the sequence of stratigraphic events to be constrained.

Methods

The samples being analyzed were collected from the delta during the summer of 2016. They were collected from 3 locations near the delta, at three separate elevations below and above the water level. The three elevations coincide with the 3 different terrace levels (Manzur, Kabansk, and Barani Mis). The first terrace level (Manzur) sat at water level and was sampled down 80 cm, every 10 cm. It is a partially lithified sediment, poorly sorted and full of hematite. The second terrace level (Kabansk) sat at an elevation of 5 meters above the lake, this middle terrace, was sampled down 210 cm, every 10 cm. The third and highest elevation terrace level (Barani Mis) sat at an elevation of 12 meters above the lake, was sampled down 100 cm, every 10 cm. Figure 1 (see appendix), shows exact sampling locations and terrace elevations.

To begin studying, the samples were analyzed under 25x and 40x magnification in order to describe the mineralogy, sorting, shape, and roundness. Each sample was then analyzed for particle size using either the Microtrac Partan3D, the WATER MACHINE, and by hand depending on the average relative particle size. The distributions of the particle sizes per each sample were then calculated and analyzed.

Once particle size was recorded, sample preparation was able to move onto the process of quartz purification. To begin with before any chemical process, the samples must be sieved and pulverized to the same uniform size. A sieve sequence of >2mm, >500um, and >125um was ran and weighed before being pulverized to a uniform particle size between 500 um to 125 um. After which, each of the 24 sample was leached of magnetic minerals, by running the dry sample through a funnel-magnet device three times, followed by running the individual samples through the paramagnetic separator three times. After undergoing the magnetic separation, each sample was processed on the wilfley table to sort the sediments compositionally, collecting the lighter minerals, and removing the heavy minerals. Currently at this point in the study, the

mechanical processing is complete and the next step is too move onto the chemical processing.

Future Research Steps

In the coming weeks, the chemical processing component of the quartz purification will proceed to finish purifying the quartz. The next five steps are (Riebe, 2012):

1. Nitric Acid Leaching: At this step, nitric acid is added to the slurry of water and sediment in order to remove carbonates and residual metals from the sample. The nitric acid will also break down any organic materials in the sample.
2. Froth Flotation: By this step, we are trying to separate the quartz, from the micas and feldspars that are within the sample. Chemically pretreating the sample will make the feldspars and micas hydrophobic, while the quartz stays hydrophilic. It will allow separation of almost all the feldspar/micas and the quartz.
3. HF Leaching: Hydrofluoric Acid will be used to leach off any remaining feldspar and to remove the very outer layer of the quartz in an effort to remove the meteoric ^{10}Be from the surface. This is very important because to analyze the radionuclide data, we want to be analyzing only the Beryllium 10 that is from inside the quartz crystal lattice.
4. Heavy Liquid Separation: Using the laboratory heavy liquid will separate any minerals left that are not quartz from each sample. This process allows density difference between the quartz, and other minerals such as zircon or rutile, that may be left, to allow separation of those minerals from the quartz that is desired.
5. Ultrasonic Etching: At this final step, each sample will be submitted to ultrasound treatment during three cycles of etching. This is a crucial step because it removes any possible meteoric ^{10}Be left from the surface of the quartz and any remaining heavy liquid from the quart's surface.

After chemical processing has been completed and the result is purified quartz for each individual sample, the next step that will be taken in the coming months, will be to send the purified quartz samples to an accelerator mass spectrometer for analysis. The data that the AMS sends back will allow us to use a series of equations to calculate the surface exposure and allow us to constrain the histories. The equations work together to account for variabilities and errors in the nuclide production rates. The necessary equations are listed and described in Chart 1 located in the Appendix.

Potential Results

This study has the potential to produce varying results regarding the stratigraphic and geomorphologic stories dependent on the absolute ages of the sediment samples. The analysis of the surface exposure histories will allow either confirm or deny the current hypothesis. The two hypotheses that are currently the strongest due to observational and stratigraphic data are discussed in the following paragraphs. Figure 2 in the appendix describes the physical locations of stratigraphic units that will be discussed within the hypotheses.

The first hypothesis is that at the start of Quaternary period, the Selenga river, deposited the Barani Mis sediments. The Selenga River avulses to the northeast and deposits the Manzur sediment. Next during the middle Pleistocene, the Selenga avulses again, this time to the southwest, depositing the far southern lobe. The Selenga River avulses a third time, back to the northeastern lobe, deposits the Kabansk sediments on top of the Manzur. These avulsions were likely caused by tectonic subsidence forcing the river to accommodate to the path of least resistance. The climate changes rapidly at beginning of Holocene, leaving from the glacial cycle to the interglacial cycle, this rapid climate change, causes increased erosion, due to the melt runoff and isostatic rebound from glacial recession, cutting through the

Kabansk, and exposing the Manzur. Deposition in the northeast continues today creating the modern lobe.

The second hypothesis is that during the Pleistocene, the increased glaciation contributed to substantial deposition of sediment, depositing the Manzur, the Kabansk, and then the Barani Mis terraces in sequence. At some time before deposition of the Barani Mis terrace, avulsion of the river likely due to tectonic subsidence was pushing the river from the northeast to the south, and back again. As the Holocene began, the rapid change in climate from a glacial cycle to an interglacial cycle, caused increased erosion due to the increased melt runoff and isostatic rebound as the glaciers receded. This runoff, eroded through all three terraces, eroding almost completely the Barani Mis, and exposing the Kabansk and Manzur terraces, leaving the terrace structure observed today.

Conclusions

This study of the Selenga River delta's stratigraphic history and surface geomorphology by analyzing the surface exposure rate through concentration of Beryllium 10 in the three terrace profiles, will help us to constrain the sequence of events and further understand how the Selenga River delta is functioning in response to climatic and tectonic forcing's, which can then be applied to our understanding of other shelf edge delta systems.

Appendix:

Chart 1:

Equations for Surface Exposure Dating of Cosmogenic Nuclides	
$P(z) = P_0 e^{-z/(z^*)}$	- This equation is the basic explanation of exponentially decreasing radionuclide production with depth. - Where P_0 is the initial value and z is the ratio of the absorption path and the material density.
$N(z, t) = N(z, 0)e^{-\lambda t} + \frac{P_0}{\lambda} e^{-\frac{z}{z^*}} (1 - e^{-\lambda t})$	- The equation is for calculating the rate of Beryllium decay of an exposure at a constant depth. - Where $\bar{N}$ is the cosmogenic nuclide mean concentration at any depth. - Lambda is the decay constant and t is time.
$\bar{N}(z) = \bar{N}_{in} + N_s e^{-z/(z^*)}$	- The equation leaves two unknowns and gives a full profile of mean concentrations within the samples, must be a relatively short period of time. - N_s is the nuclide accumulation at the surface since deposition. - $\bar{N}_{in}$ is the initial value of mean pre-depositional inheritance.
$\tau = \frac{1}{\lambda} \ln \left(\frac{\Delta P}{\Delta P - \lambda \Delta \bar{N}} \right)$	- This equation uses the pairs technique, to date the age of the surface samples. - Where $\Delta P = P_0 - \frac{p(z_s)z^*}{L} * (e^{\frac{L}{z^*}} - 1)$ and is a function of time. - L is the measured depth.
$R(L) = \frac{z^*}{L} (e^{\frac{L}{z^*}} - 1)$	- This equation is used to calculate in the case that the rate of nuclide production was not constant and adjusts for silt thickness.
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Figure 1:

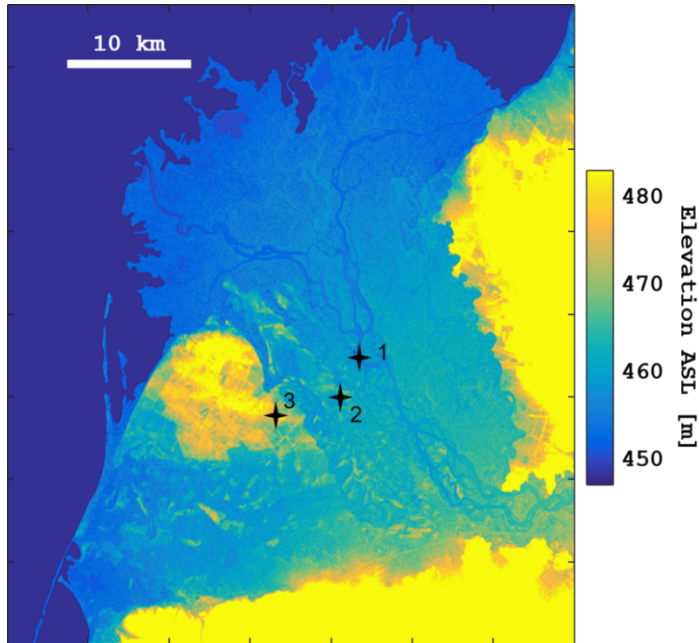
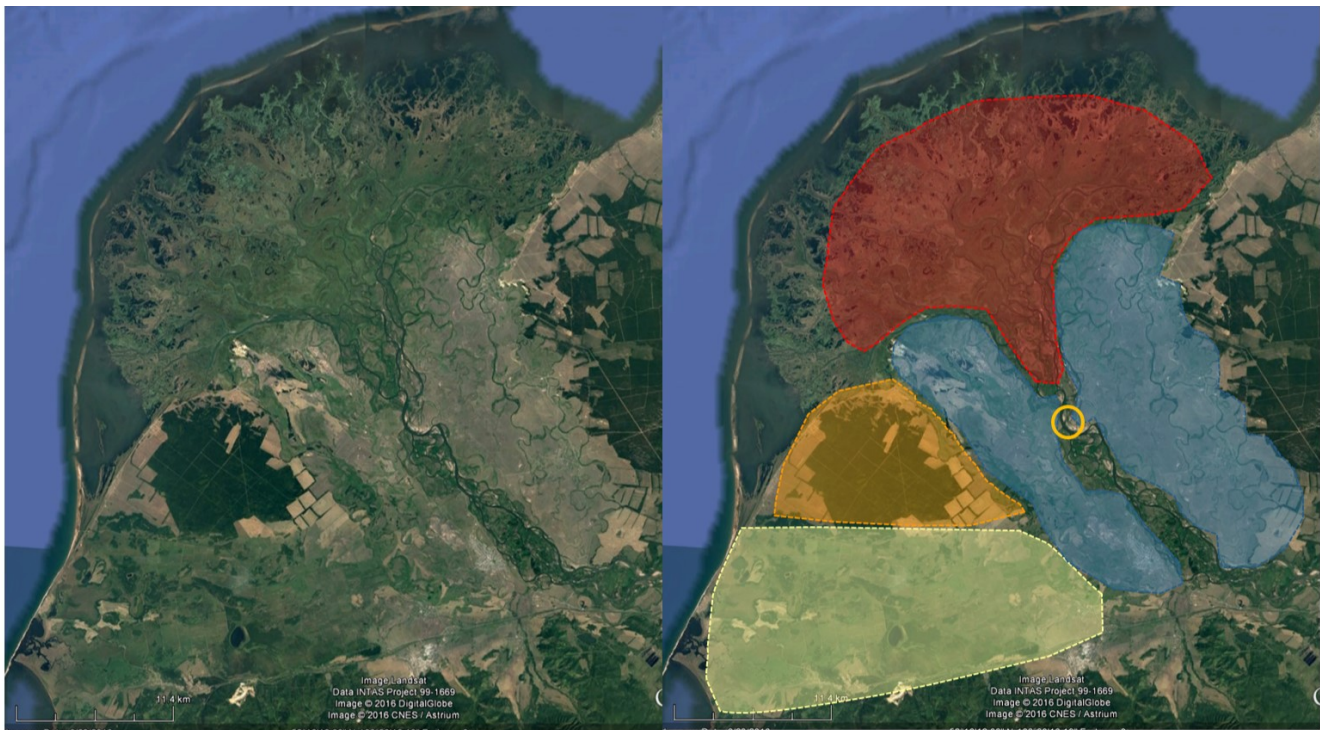


Figure 2:



- Red — Modern/Northeastern Lobe
- Yellow — Southernmost lobe
- Blue — Kabansk Terrace
- Orange — Baranie Mis Terrace
- Circle — Manzur Terrace

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Marissa Murr

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Graduate Student Mentor: Jason Alexander

Research Topic: Relating Bar Formation to Changes in Sandy River Channel Width in Relation to Piping Plover and Least Tern Nesting Incidence

Introduction

Threatened Northern Great Plains piping plovers (*Charadrius melodus*, plovers) and endangered interior least terns (*Sternula antillarum athalassos*, terns), recognized under the Endangered Species act of 1973, are migratory bird species that use sandbars for nesting and brooding habitat (Alexander et. al, 2012). Therefore, concluding if sandbar area is dependent on other geomorphological characteristics, like width, is significant to understanding why birds select nesting locations on wider than average reaches of river (Jorgenson 2012).

The data for this project includes remotely collected, natural color, three-band imagery as well as false color, near-inferred, four-band images of the Platte and Niobrara River. The aerial images used for analysis are available to the public and have been collected by various government agencies including the Nebraska Department of Natural Resources. By using ArcGIS to classify images, large portions of river sections (100km+) can be analyzed and compared. Multiple datasets are used to do a larger scale analysis of the subject; four years of the Lower Platte River are classified as well as two years of the Lower Niobrara. By analyzing multiple years of data, trends that are found may be shown to occur over multiple years proving the trend is not an anomaly and is statistically significant. Calculating the area of dry exposed sand in the channel and comparing this data to the local channel width will show if there is a correlation between changes in width and the amount of exposed sand, which is an indication of nesting habitat (Jorgenson 2012).

Problem

Lack of understanding about sandy rivers makes predicting river behavior difficult, which effects wildlife as well as infrastructure. When humans interfere with natural systems, it is important to understand the system to predict potential consequences. Habitat for the endangered terns and threatened

plovers has been reduced as the result of human influence; the channelization of rivers eliminates naturally occurring sandbars (Alexander et al. 2012). Efforts to rebuild sandbars, to increase habitat area, have failed because the sand is not deposited in a natural way that is conducive to the continued presence of exposed sand (Jorgenson 2012). The aim of this research is to improve overall knowledge of the characteristics that control where sand is deposited, which will hopefully aid in future decision making regarding the alteration of riverine environments.

Background Information

The Governors of Wyoming, Nebraska and Colorado agreed to maintain habitat the endangered and threatened animals. The species protected in this statewide agreement included the whooping crane, interior least tern, piping plover, and pallid sturgeon (Bureau of Reclamation and Fish and Wildlife Service 2006). The agreement makes it so federal water projects, and state and private water activities which require Federal permits or funding, must prove the activity will not increase the chance of extinction for any of the threatened or endangered species.

Due to human activity, as much as 90 percent of habitat used by three of the four species has been eliminated due to human interference with the natural hydraulic system (Bureau of Reclamation and Fish and Wildlife Service 2006).

The depletion of natural habitat in the lower Platte River resulted in fewer nesting opportunities for the interior least tern (terns; *Sterna antillarum* athalassos) and the piping plover (plovers; *Charadrius melodus*). The threatened least tern and endangered piping plover nest on mid-channel sandbars in the Platte River as well as on gravel beds in lakes in the valleys surrounding the Platte River (Alexander, Schultze and Zelt 2011). These birds migrate up from the Central American coast and northern South American coast reaching as far south as Brazil . Nesting is observed in May and June and sometimes as early as April. The birds may stay as late as August. Most of the images acquired during June and July to investigate sections of river that have established nests.

The current research includes many studies done for one year in one location. There are also studies like (Farnsworth, et al. 2017) that review the flaws in methods used by other papers. The papers written provided evidence that is useful to my own research. However, papers were not found that compared detailed temporal characteristics to changes in nesting incidence. Farnsworth et al. 2017 touched on this subject by showing how birds do not typically

nest after peak flood, which compared data from different years for the Platte River. However, this study did not include multiple rivers. If data can be normalized so comparison between multiple sandy rivers can be made, a more general understanding of how such river systems behave can be concluded. This information will be helpful for making connections between habitat areas and nesting incidence as supported by multiple datasets rather than data for one place and one year, which does not account for variability in the river systems that may exist. As pointed out by Werbylo et al. 2016, inconsistencies in analysis of aerial imagery pertaining to river width must be considered when doing analysis.

Methodology

The data for this project includes high spatial resolution aerial imagery (1 meter) of the rivers studied. Examples of the images analyzed and the results of classification are shown in Figures 1, 2 and 3. From the classified images, the area of dry exposed sand was extracted and the average channel width was determined. I used ArcGIS to complete the classification process is like the technique described by Elliot (2011).

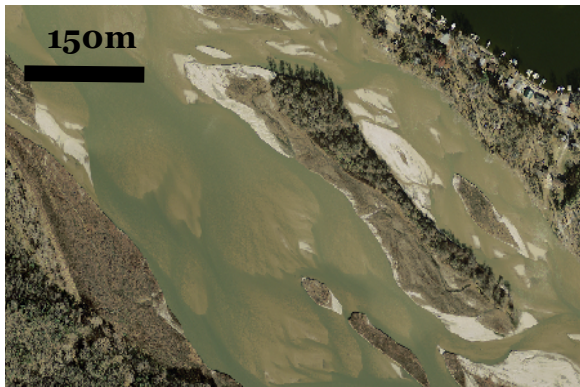


Figure 1.
This photo is a 3-band, visible color image of a portion of the Lower Platte River with 1 meter spatial resolution.

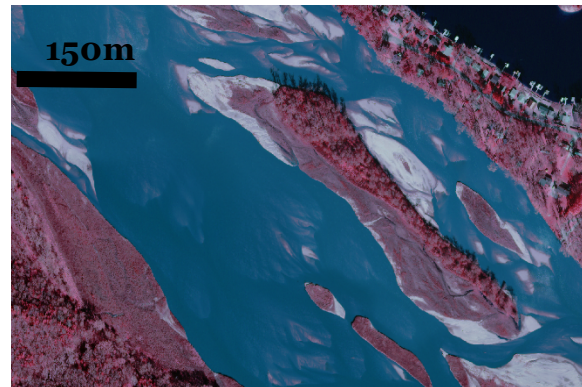


Figure 2.
This photo is a 4-band, false color inferred image of the same portion of the Lower Platte River. Notice the more distinct contrast in colors making a 4-

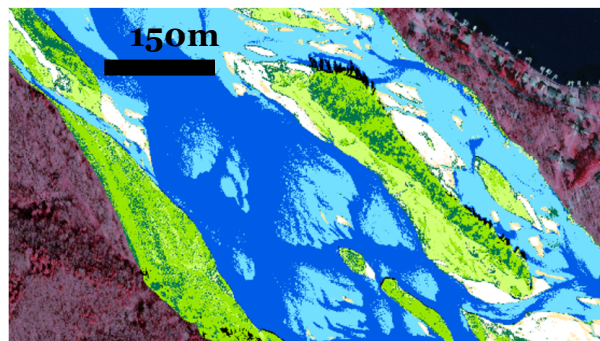


Figure 3.

This figure is the same section of river that has been classified. All the classes are classified down to the individual pixels, so the area can be calculated by using a computer to count the number of pixels of each class.

First, I digitized the banks of the river manually, and to stay consistent with other research projects, the banks of the river were determined by the active river channel. Digitizing banks based on the active channel is the same technique as used by Jorgenson et al. (2012) and Elliot et al. (2009).

After digitizing the riverbanks, I split the portion of active river channel into individual segments, so I could compare spatial and temporal changes in class areas. Examples of the segment and digitized channels are shown in Figure 4. The length of each segment is constant throughout the river system; the length of each segment was chosen based on the historic average of channel width for the entire river.

Average river width is an appropriate measurement for segment length because sandbars grow to the length of one channel width (Alexander et. al. 2011). The length of the sections selected for the Lower Platte River was 500m and for the Niobrara River 330m segments were selected; by allowing segment width to depend on average width of the entire river, the process of selection for segment length may be applied to multiple rivers systematically.

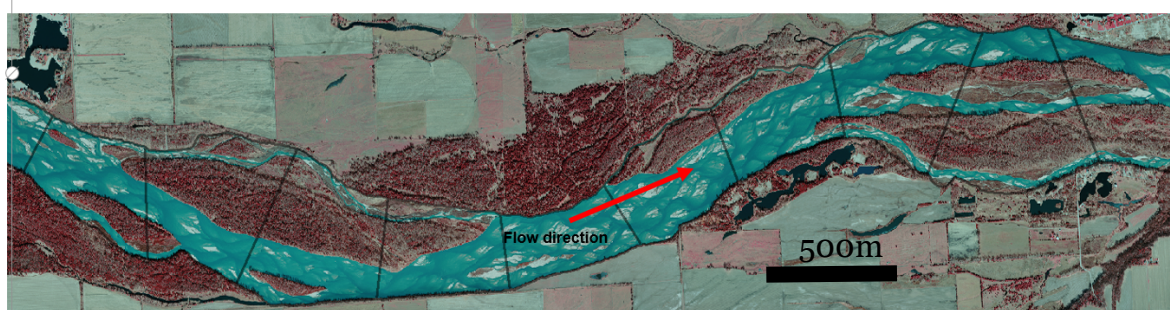


Figure 4.

False color image of a portion of the Lower Platte River that was analyzed. The channel bound polylines and sampling boundaries (500m) are shown with the black lines.

Average active channel width was then measured by dividing the total active area of the section by the length of the section. The active area of the section is the portion of river that includes all classes except the islands (classified as light and dark vegetation in Figure 3), which do not change at the same rate as sandbars.

To classify the images, I conducted multiple supervised image classifications to extract coarse-scale physical habitat characteristics. Training classes were manually created to inform statistical characterization of each habitat class. Classification is then performed using the Maximum Likelihood Classification tool in ArcGIS. Using a computer program to classify images, rather than manually classifying images, makes the process repeatable.

During the classification process each pixel is assigned a number value dependent on its assigned class. Each value is associated with a color so the classification can be viewed in a digital image allowing the classifier to visually check accuracy of the classification. The program R was then used to extract area information from the image once it had been classified. A complete classification of a section of river is shown in Figure 3 where the classified pixels are colored to represent the habitat.

R, a statistical processing program is then used to statistically analyze the relevant data. The variables of interest are river width, sand area, vegetation area, and continuous sand area. Continuous sand area is relevant because the plovers and terns seem to prefer nesting on larger (2+ acre sandbars).

Results

Niobrara River

The portion of the Niobrara analyzed is consistent for the two years, so the two years can be compared. Each image included 60kms of the Niobrara River. The study area began 60km upstream of the Missouri River and ended at the junction with the Missouri River.

2012

The results for the Niobrara show there is a correlation between riverine habitat and bird nesting locations. The sample size for this year is very low. There were seven sections of river that had bird nests present and 33 total nests in the reach of river analyzed. Width, total sand area and vegetation were analyzed for the Niobrara River for 2012.

The two years of data analyzed from the Niobrara River indicate there is a significant correlation between local width and

local sand area. For 2012 channel width in meters correlated to total sand area in meters with an r -squared value of 0.51. This correlation is of interest because the geomorphology of the river could be determining where the habitat is.

The locations in which the birds were nesting for 2012 indicate birds are selecting for areas of greater width (p -value=0.0488). Birds nested on areas of river with an average width of 369 m versus the channel mean of 248 m.

The locations in which the birds were nesting for 2012 indicate birds are selecting for areas of greater width (p -value=0.14). Birds nested on areas of river with an average sand area of 3.37 hectares versus the channel mean of 2.3 hectares.

The locations in which the birds were nesting for 2012 do not indicate birds are selecting for areas of greater vegetation area (p -value=0.85). Birds nested on areas of river with an average vegetation area of 3.27 hectares versus the channel mean of 2.92 hectares.

The difference in means for sand area and width indicate there is an important correlation even though the p -values are higher than typical thresholds due to the low sample size.

2014

The results for the Niobrara show there is a correlation between riverine habitat and bird nesting locations. The sample size for this year is very low. There were seven sections of river that had bird nests present and 33 total nests in the reach of river analyzed. Width, total sand area and vegetation were analyzed for the Niobrara River for 2012.

The two years of data analyzed from the Niobrara River indicate there is a significant correlation between local width and local sand area. For 2012 channel width in meters correlated to total sand area in meters with an r -squared value of 0.51. This correlation is of interest because the geomorphology of the river could be determining where the habitat is.

The locations in which the birds were nesting for 2014 indicate birds are selecting for areas of greater width (p -value=0.16). Birds nested on areas of river with an average width of 338 m versus the channel mean of 233 m.

The locations in which the birds were nesting for 2014 indicate birds are selecting for areas of greater sand area (p -value=0.5662). Birds nested on areas of river with an average sand area of 5.07 hectares versus the channel mean of 2.8 hectares.

The locations in which the birds were nesting for 2014 do not indicate birds are selecting for areas of greater vegetation area

(p-value=0.77). Birds nested on areas of river with an average vegetation area of 3.55 hectares versus the channel mean of 2.77 hectares.

The difference in means for sand area and width indicate there is an important correlation even though the p-values are higher than typical thresholds due to the low sample size.

Platte River

The 2012 analysis of the Lower Platte River was excluded because the images were taken in September and likely do not reflect the habitat in which the birds were nesting. This is because that late in the year there are floods that may reshape the river meaning sandbars will move from where the birds were nesting.

2006

The results for the Lower Platte River show there is a correlation between riverine habitat and bird nesting locations. There were twelve sections of river that had bird nests present and 85 total nests in the reach of river analyzed. Width, total sand area, continuous sand area and vegetation were analyzed for the Lower Platte River for 2006.

The locations in which the birds were nesting for 2006 indicate birds are selecting for areas of greater width (p-value=0.048). Birds nested on areas of river with an average width of 465 m versus the channel mean of 400 m.

The locations in which the birds were nesting for 2006 indicate birds are selecting for areas of greater continuous sand area (p-value=0.053). Birds nested on areas of river with an average continuous sand area of 6.41 hectares versus the channel mean of 4.45 hectares.

The locations in which the birds were nesting for 2006 indicate birds are selecting for areas of greater continuous sand area (p-value=0.024). Birds nested on areas of river with an average sand area of 8.4 hectares versus the channel mean of 6.25 hectares.

The locations in which the birds were nesting for 2006 do not indicate birds are selecting less vegetation area (p-value=0.07). Birds nested on areas of river with an average vegetation area of 4.29 hectares versus the channel mean of 6.58 hectares.

The difference in means for sand area and width indicate there is an important correlation even though the p-values are higher than typical thresholds due to the low sample size.

2010

The results for the Lower Platte River show there is a correlation between riverine habitat and bird nesting locations. There were nine sections of river that had bird nests present and 22 total nests in the reach of river analyzed. Width, total sand area, continuous sand area and vegetation were analyzed for the Lower Platte River for 2010.

The locations in which the birds were nesting for 2010 indicate birds are selecting for areas of greater width (p-value=0.26). Birds nested on areas of river with an average width of 435 m versus the channel mean of 472 m.

The locations in which the birds were nesting for 2010 indicate birds are selecting for areas of greater continuous sand area (p-value=0.04). Birds nested on areas of river with an average continuous sand area of 5.45 hectares versus the channel mean of 2.92 hectares.

The locations in which the birds were nesting for 2010 indicate birds are selecting for areas of greater sand area (p-value=0.037). Birds nested on areas of river with an average sand area of 5.98 hectares versus the channel mean of 3.4 hectares.

The locations in which the birds were nesting for 2010 indicate birds are selecting for areas of lesser vegetation area (p-value<0.05). Birds nested on areas of river with an average vegetation area of 1.56 hectares versus the channel mean of 5.69 hectares.

The difference in means for sand area and width indicate there is an important correlation even though the p-values are higher than typical thresholds due to the low sample size.

2014

The results for the Lower Platte River show there is a correlation between riverine habitat and bird nesting locations. There were nine sections of river that had bird nests present and 16 total nests in the reach of river analyzed. Width, total sand area, continuous sand area and vegetation were analyzed for the Lower Platte River for 2014.

The locations in which the birds were nesting for 2014 indicate birds are selecting for areas of greater width (p-value=0.12). Birds nested on areas of river with an average width of 484 m versus the channel mean of 426 m.

The locations in which the birds were nesting for 2014 indicate birds are selecting for areas of greater continuous sand area (p-value=0.21). Birds nested on areas of river with an average continuous sand area of 4.69 hectares versus the channel mean of 3.23 hectares.

The locations in which the birds were nesting for 2014 do not indicate birds are selecting for areas of greater or lesser vegetation area (p -value=0.99). Birds nested on areas of river with an average vegetation area of 5.97 hectares versus the channel mean of 5.97 hectares.

The difference in means for sand area and width indicate there is an important correlation even though the p -values are higher than typical thresholds due to the low sample size.

Discussion

Niobrara River

The images for the Niobrara River in 2012 were four band, false color inferred imagery. From the 2012 photos, eight distinct classes were created, but were later combined into four classes (vegetation, dry sand, wet sand, and water). Images collected in 2014 were 3-band, visible color images; classification of 3-band imagery is more difficult because of the spectral confusion resulting in the creation of four classes instead of eight. Because of the difference in classes the 2012 images were reduced to four classes so comparisons between the years could be made. Reduction of classes was done by combining classes from the 2012 images that were considered one class in the 2014 imagery.

Because the images are a mosaic of different images taken at different times of the day, there may be some discrepancy within the photos themselves resulting in possible error.

The difference in the p -values between the 2014 data and the 2012 data could be attributed to the differences in detail obtained from the images. However, because corrections were made for the discrepancy, it seems likely the higher flow rates in 2014 may have formed larger and more stable sandbars that could survive until the images were taken in September. The formative flooding periods are outlined in table 1 showing how 2014 had higher flow rates in the months prior to the image. The higher flow during the period in which the images were taken could also mean water was covering sandbars that were small or dissected resulting in data that does not include random patches of sand. Because it is believed sandbars grow to the height of the water surface, higher flows would result in taller and larger sandbars. Lower flow rates result in more dissected, smaller bars that are more susceptible to erosion (Alexander et. al. 2013). It is also possible differences between years also resulted as the random variability that occurs in chaotic systems.

Further Research

Further research calculating in more factors like the Rousse number and discharge would likely create a clearer correlation between river characteristics and bird nesting incidence. Variability in flow conditions can greatly impact these results. Since river systems are dynamic and complex, correlations are typically not perfectly linear and a variety of factors must be considered to begin to understand relationships and controls on the morphology.

Conclusion

In some instances, width correlates the amount of sand area. However, due to a variety of factors this is not always true; the Platte River shows no correlation. Because the data shows a wide variety of correlation between sand area and width, there are likely other factors influencing how much sand is being deposited. Factors like discharge, slope and percent of vegetation are all likely to have an impact on sand area, so further analysis must be done to accurately predict where sand may be deposited.

It is clear there is some correlation between sand area and channel width compared to bird nesting incidence because the trend occurs over many years in two different rivers showing the relationship is not a fluke observation. It appears the vegetation is sometimes negatively correlated to bird nesting incidence. However, it does not happen in all or most years indicating there is not an overarching relationship.

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Graduate Student Mentor: Karlee Provenza

Research Topic: Geographic Mobility of Serial Killers: Is Anger and Aggression a Predictor?

Introduction

"I'm so mad I could kill someone!" This phrase is used almost every day by a wide range of people. Children use it when another child takes his or her toy, teenagers use it when a friend makes a rude comment or hangs out with a different friend, adults say it when they had a bad day at work, but what stops people from actually killing another person when they are so angry? Maybe because it is against the law or maybe just because it is morally wrong (Miller, 2014b). There are many reasons that individuals don't kill others every time they get mad, so the better question is, what drives an individual to kill another person when he or she is extremely angry? Serial killers are an intriguing topic that have always fascinated the minds of psychologists and criminologists. They seek to answer questions like the ones above and many others. The present research was used to determine if anger and aggression play a role in geographic mobility of a serial killer. Homicide cases generally lack communication between different task force agencies and data of cases tend to be disorganized (Johns et al., 2008). These issues in serial killer cases result in an inability to label the suspect as a serial killer, which ultimately slows the investigation because each task force is only working with half of the information for the case (Johns et al., 2008). If certain offender characteristics that can be indirectly observable at crimes scenes can help predict distance traveled by the offender for the victim, crime scene variables may help in informing investigators where to look for suspects. The present study examined whether levels of anger and aggression of serial killers were predictive of how far they traveled to find their victims.

Serial Killers

The most common definition of a serial killer is an individual who commits at least two murders, on two different occasions, over a period of time with a cooling off period in between (Johns et al., 2008). Serial killers do not just begin killing but rather live a life of crime before their first victim (Miller, 2014). During adolescence, individuals who will later become serial killers begin engaging in behavior such as assault and battery, which then evolves into rape and arson and eventually murder (Miller, 2014b). Criminal adolescence is commonly, although not always, a result of a neglected and rejected childhood in which they experienced sexual and physical abuse, isolation, and a lack of love (Miller, 2014b). Serial killers are most commonly white, male, and between 20 and 30 years old (Miller, 2014a). Classification systems, looking at methods and motivations of the serial killers have been created (Miller, 2014). These classification systems look at things such as duration of the violent act (i.e. did the perpetrator kill the victim quickly or take their time), involvement of torture, presence of a weapon, sexual gratification or motivation, power motivation, and many other factors (Miller, 2014). These systems also take into account whether or not the killer was geographically stable or geographically transient (Miller, 2014). However, these systems do not look at anger and aggression when classifying the killer as this study will do.

Anger

There are many different types of anger that can be measured. These types of anger include state anger, trait anger, and anger expression. Anger can affect cognition, arousal, and behavior (Mela, Balbuena, Duncan, Wong, Gu, Polvi, & Gordon, 2008, Novaco & Chemtob, 2002). The State-Trait-Anger Expression Inventory measures (STAXI) and the Novaco Anger Scale (NAS) measure these different types of anger and how they affect individuals, however, they do not explain what causes the anger, (Mela, Balbuena, Duncan, Wong, Gu, Polvi, & Gordon, 2008, Novaco & Chemtob, 2002). Previous research has sought to explain why anger occurs.

An anger state may be triggered by a range of stimuli such as other people, the environment, physical and psychological distress, and interpersonal demands (Kashdan,

Goodman, Mallard, & DeWall, 2016). Triggers such as exposure to violence between parents, frequent and severe punishments such as emotional and physical abuse, early childhood trauma, and disorders such as XY, delusions, psychopathy and Antisocial Personality Disorder (ASD) result in the individual being in a constant state of anger (Ioana, 2013; Nelligan, 2013; Ullrich, Keers, & Cold, 2014). This constant state of anger for a prolonged period of time results in difficulties with emotion regulation, suppression of anger, physical and verbal aggression, and lashing out (Gardner, Moore, & Dettore, 2014; Kashdan et al, 2016). Prolonged anger could explain why some killers do not travel for victim selection.

When individuals experience an anger triggering event that is not expected, or difficult to understand, reactions are intense, out of proportion, and more difficult to control (Ullrich et al., 2014). The triggers mentioned above, are more commonly found in a criminal population than in the general population which helps explain how criminals slowly become violent (Allely, Minnis, Thompson, Wilson, & Gillberg, 2014; Ioana, 2013; Miller, 2014a). For example, the prevalence rate for XY is ten times more likely in a criminal population (Ioana, 2013), and ten percent of serial killers have ASD which is higher than the trend among the general population, which is around three percent in men and one percent in women (Allely et al., 2014; Kivi, 2016). Both disorders, as well as psychopathy, lead to violent acts and are more prevalent in serial killers (Ioana, 2013). The reason psychopathy results in violent acts is because these individuals have no conscience or feelings for others and so they do what they want and have no regrets (Ioana, 2013). Although these disorders are common in the criminal population, no research has looked at how, or if these events cause anger in people categorized as serial killers.

People who are exposed to triggers of anger over a long period of time are often more easily angered. As this anger continues to bottle up, individuals enter what is called the evil violence tunnel (Allen, Bethell, & Allen-Carroll, 2016). Within the evil violence tunnel, an individual's rage is either taken out on himself in forms of self-injury and even suicide, or it is taken out on other people or things (Allen et al., 2016). An example of this can be seen in individuals who experience early childhood trauma, which is very common in the serial killer population. As the trauma continues, anger becomes bottled up and then results in the evil violence

tunnel phenomenon (Allen et al., 2016). While in the evil violence tunnel, individuals experience an aroused state of elevated blood pressure and heart rate, which blocks input from the brain. This lowers their cognitive capacity to respond which leads to violent behavior. The individual cannot walk away from the situation because the amygdala processes information outside of conscious awareness at this point which results in a reaction before the individual even consciously processes what is happening (Allen et al., 2016). The individual has no sense of fear and all thoughts of hurt are shifted to repeated destructive behavior such as stabbing others or themselves. Once the destructive act is over, the individuals feel a sense of release and exhaustion (Allen et al., 2016). Although the evil violence tunnel has never been examined in the serial killer population to determine if this occurs during a killing, the nature of the evil violence tunnel helps explain crimes such as domestic violence and murder.

Aggression

Aggression is a behavioral response to anger which is categorized into two types: hostile and instrumental aggression (Bushman & Anderson, 2001). Those demonstrating hostile aggression are acting out of impulsivity with the goal of harming others (Gardner, Moore, & Dettore, 2014; Bushman & Anderson, 2001). Instrumental aggression, on the other hand, is premeditated with other goals in mind, such as gaining money, getting revenge, or to restore one's image (Gardner et al., 2014; Bushman & Anderson, 2001). Aggression, as measured by the Aggression Questionnaire (AQ), has multiple domains: a motor component, an affective component, and a cognitive component (Buss & Perry, 1992). However, similar to anger, the measures do not explain what causes some individuals to engage in aggressive behaviors while others do not.

Many people believe that venting anger through aggressive acts will reduce anger, however, previous research shows that venting actually increases feelings of anger (Bushman, 2002). As an individual vents, more aggressive thoughts and feelings are activated (Bushman, 2002). This relates to serial killers because serial killers are acting out of aggression when they kill another individual. Venting the aggression makes them angrier and more aggressive which explains why they kill multiple individuals (Bushman, 2002). Serial killings are typically irrational acts and therefore represent hostile

aggression (Ioana, 2013, Gardner et al., 2014; Bushman & Anderson, 2001). As a serial killer engages in aggressive acts, the killer's blood pressure drops creating a calming feeling to the individual (Ioana, 2013). During the violent acts, and immediately after, individuals report a feeling of nothingness. (Gardner & Moore, 2008). However, shortly after, they show high levels of anger and aggression again (Gardner & Moore, 2008). This suggests that serial killers use violent behaviors as a way to escape their anger but due to the fact that venting anger makes an individual angrier shortly after a killing, they experience more anger and aggression which leads them to continue engaging in violent acts such as murder (Gardner et al., 2014, Robertson et al., 2014, and Gardner & Moore, 2008). Because of the research on anger and aggression showing causes and how it relates to crimes such as murder, it was thought that the constructs of anger and aggression would be informative when looking at the whether or not anger and aggression play a role in victim selection of serial killers.

The Current Study

The current study sought to determine if anger and aggression levels play a role in where serial killers choose their victims. Understanding geographic mobility of serial killers, or how far a killer will travel for a victim, can aid in investigations. Levels of aggression displayed during an offense can be interpreted from a crime scene by looking at things like use of a weapon/type of weapon, blood region/amount of blood, and whether or not the body was moved/hidden (Santilla, Hakkanen, Canter, & Elfgren, 2003). If aggression is related to how far serial killers are willing to travel to get their victims, it can be better estimated how big of a span this serial killer will travel based on how much aggression is displayed at the crime scene. This is important because it can have many implications such as helping investigators determine where to look for a killer and help them predict where he or she will attack later. This will increase communication among task forces and encourage them to share data. Also, if other victims in different locations can be associated with the same killer, then there will be more evidence to analyze to determine who the killer is. This could lead to more frequent and faster convictions. Understanding how far a serial killer is willing to travel can also help to pinpoint a location for where the serial killer may live.

Previous research has been conducted on anger and aggressing to determine how it effects an individual and their behavior. Based on research stating that anger leads to deficits in emotional regulation which in turn leads to fewer attempts to control aggression (Gardner et al., 2014; Kashdan et al, 2016), as well as research on the evil violence tunnel (Allen et al., 2016), and research on aggressive acts provoking more aggressive thoughts and feelings (Bushman, 2002), it is hypothesized that serial killers who display higher levels of anger and aggression will be less likely to travel away from their hometown to find their victims to engage in killing. Specifically, it was hypothesized that higher levels of anger and aggression as measured by the STAXI (Mela et al., 2008), the NAS (Novaco, 1994), and the AQ (Buss & Perry, 1992), the shorter the killers geographical span will be.

Methods

Participants

Eighty-one participants filled out two anger scales and one aggression scale for this study. From these eighty-one participants, seven were eliminated because they were female, thirteen were eliminated because they were not classified as a serial killer, and seventeen were eliminated because victim information could not be found. This left a total of forty-four victims to be used in this study. Of these forty-four, 80% indicated they were White, 9% African American, 2% Hispanic, and 9% other. The participants ranged in age from thirty-two to seventy-three years old.

Materials

STAXI

The State-Trait-Anger-Expression-Index (STAXI), is a 44-item self-report scale used to measure both experience and expression of anger of a 4-point Likert scale (Mela et al., 2008). The STAXI measures experience anger by looking at state anger, or anger at a given point of time, and trait anger, anger over a period of time (Mela et al., 2008). It measures expression anger by looking at suppression of anger, externalization of anger, and ability to control anger (Mela et al., 2008). STAXI has an internal reliability of Cronbach's $\alpha > 0.72$ (Mela et al., 2008).

NAS

The Novaco Anger Scale (NAS) is a self-report scale used to measure anger disposition (Novaco & Chemtob, 2002). The NAS consists of 60 items measured using a 3-point Likert scale (Culhane & Morera, 2010). Anger is measured through three domains, cognitive, arousal, and behavioral (Novaco & Chemtob, 2002). Cognition looks at areas such as attentional focus, suspicion, rumination, and hostile attitude (Novaco, 1994). Arousal looks at areas of intensity, duration, tension, and irritability (Novaco, 1994). Behavior looks at areas of impulsive reaction, physical confrontation, verbal aggression, and indirect expression (Novaco, 1994). The NAS has an internal consistency of 0.95. It also has high test-retest reliability, 0.84, and good predictive validity (Novaco, 1994).

Aggression Questionnaire (AQ)

The aggression questionnaire (AQ) is a 29-item measure used to examine three domains of aggressive behavior on a 5-point Likert scale (Buss & Perry, 1992). The three domains of behavior assessed are the instrumental or motor component, the emotional or affective component, and the cognitive component (Buss & Perry, 1992). The instrumental/motor component is measured by looking at physical and verbal aggression, the intentional hurting or harming of others (Buss & Perry, 1992). The emotional/affective component is assessed by looking at anger, physiological arousal and the preparation for anger (Buss & Perry, 1992). The cognitive component of behavior is assessed by looking at hostility, feelings of ill will and injustice (Buss & Perry, 1992). Test-retest reliability of the measure varies by factor: Physical aggression, .80; verbal aggression, .76; anger, .72; hostility, .72; and total score, .80 (Buss and Perry, 1992). Internal consistency within the measures varies by factors as well: Physical aggression, .85; verbal aggression, .72; anger, .83; hostility, .77; and total score, .89 (Buss & Perry, 1992).

Geographic information

Multiple searches were conducted using the Internet in order to determine where the serial killer lived and where their respective victims lived. These searches were conducted using online newspapers, police records, court convictions, and serial killer encyclopedias. In order to find accurate information, the searches were conducted by using the serial killers' full name as well as the year he was incarcerated.

Procedure

550 incarcerated individuals suspected of multiple murder were contacted asking if they'd be interested in participating in a study. After receiving a willingness to participate from some of the individuals, IRB approval from each state had to be granted. Several inmates were not able to participate due to IRB decisions. For those who were allowed to participate, multiple measures, including the STAXI, NAS, and AQ, were sent to each individual. Eighty-one inmates filled out the measures and sent them back. After receiving these, searches through police records, court convictions, newspaper articles, and serial killer encyclopedias were conducted to determine whether or not these inmates were serial killers.

Once classified as a serial killer, further research was conducted through police records, court convictions, newspaper articles, and serial killer encyclopedias to determine where the killer lived and where each of his victims lived. After gathering this data, each killer was classified as either a transient killer, meaning he traveled out of the city he lived in to get his victims, or a stable killer, meaning he stayed in the same city he lived in to get his victims. A map was then used to determine the farthest distance the killer traveled for one of his victims. Since the map provided multiple routes the killer could have taken, an average of all the different routes possible was used for the distance.

Results

This research study sought to determine if anger and aggression, as measured by the STAXI, NAS, and the AQ, are a predictor for distance traveled. It was hypothesized that higher levels of anger will result in shorter distances traveled by the killer. It was also hypothesized that higher levels of aggression will result in shorter distances traveled by the killer.

STAXI

To test the hypothesis, a linear regression was used to determine if each subscale score on the STAXI predicted distance traveled for victims. Using state anger, trait anger, and the anger expression index as predictors of miles traveled, results indicated the overall model was not significant, $F(4, 38) = 1.04$, $p = 0.40$, $\text{adj. } R^2 = 0.003$. Within the full model, only trait anger approached significance, $t = 1.89$, $p = 0.07$. To further examine if the

anger expression measure on the STAXI was a predictor in distance traveled, another linear regression examining components of the STAXI was run. These regression analyses looked at state anger, trait anger, and anger expression independently to determine if they were predictors for distance as measured on a continuous variable. Again, results were not significant for any of the analyses, $ps > 0.43$. Together, results regarding measures of the STAXI fail to support hypotheses that trait and state anger, anger expression, and anger control do not predict distance traveled for victims by serial killers.

NAS

After discovering the STAXI was not a predictor for distance traveled, a linear regression was used to determine if the total score on the NAS was a predictor for distance traveled. The model showed that the NAS total score did not predict distance traveled, $F(1, 41) = 0.03$, $p = 0.87$. However, a further analysis was run to determine if the individual factors, the cognitive domain, the arousal domain, and the behavioral domain, in the NAS predicted distance traveled. The overall model was significant, $F(4, 38) = 3.34$, $p = 0.02$, and accounted for 18% of the variance in distance traveled ($\text{adj. } R^2 = 0.18$). This model showed that both the cognition factor, $\beta = 53.47$, $t = 2.98$, $p = 0.005$, and the arousal factor, $\beta = 39.60$, $t = -2.52$, $p = 0.02$, significantly predicted distance traveled. For the cognition factor, each unit increase resulted in an increase of 53.47 miles traveled, as shown in Figure 1. For the arousal score, each unit decrease results in an increase of 39.60 miles traveled, shown in Figure 2. The behavioral and regulatory components were not significant predictors of distance traveled, $ps > 0.25$.

AQ

A linear regression was run to determine if the total AQ score predicted distance traveled. The results showed that total AQ was not a significant predictor for distance traveled, $F(1, 41) = 0.34$, $p = 0.56$, $R^2 = -0.016$. A second linear regression was used to determine if the factor measures within the AQ, (physical aggression, verbal aggression, physiological arousal, and hostility) were predictors of distance traveled. Results indicated the model was not significant, $F(4, 38) = 1.21$, $p = 0.32$. However, within the factor model, the verbal aggression measure was significant, β

= 40.26, $t = 2.18$, $p = 0.04$. This shows that for each unit increase in verbal aggression scores, the distance traveled increased by 40.26 miles, shown in Figure 3.

Discussion

Serial killers are a rare population defined as killing two or more individuals on two or more occasions (Johns et al., 2008). Serial killers often lead a life of crime before turning to murder (Miller, 2014a), and often experience a childhood of neglect, rejection, sexual and physical abuse, and isolation (Miller, 2014b). As individuals experience these situations, they experience anger, and this exposure to feelings of anger for long periods of time results in the inability to regulate emotions (Gardner, Moore, & Dettore, 2014; Kashdan et al., 2016). This can then lead to aggressive behaviors, most commonly hostile aggression which is impulsive and a result of anger (Gardner, Moore, & Dettore, 2014; Bushman & Anderson, 2001). However, venting anger through aggressive acts can cause more feelings of anger and therefore, more aggression which can lead an individual to taking another individual's life, as seen in the serial killer population (Gardner et al., 2014; Robertson et al., 2014; Gardner & Moore, 2008).

The purpose of this study was to determine if levels of anger and aggression were a predictive of geographic mobility of serial killers, or whether or not the killer traveled out of the city in which he lived to get his victims. Levels of aggression can be interpreted at crime scenes by looking at things such as was a weapon used, what type of weapon was used, was the body hidden or left in plain sight, and was there a large area of blood or a small area of blood (Santilla, et al., 2003). The results indicated that the total STAXI, NAS, and AQ were not predictors of distance traveled by serial killers. However, individual factors within each measure did predict distance traveled, which makes sense given that subcategories of each measure are attempting to capture various constructs of anger and aggression.

The STAXI was not a predictor for distance traveled. The STAXI measures anger at a given time, anger over a period of time, and how an individual chooses to respond to anger (Mela et al., 2008). One explanation for why this measure didn't predict distance traveled could be that the measure does not assess how a serial killer responds to anger as accurately as

it measures how an individual from the general population responds to anger.

Although the STAXI was not predictive of distance traveled for victims, components of the NAS was predictive of distance traveled. Within the NAS, both the cognitive domain and the arousal domain showed significance in predicting travel. Individuals who possess traits outlined by the cognitive domain of anger tend to give a lot of attentional focus to negative situations, are highly suspicious, spend more time ruminating on situations that provoke anger, and have a hostile attitude (Novaco, 1994). Results from the current study demonstrated that individuals high in these cognitive traits of anger are more likely to travel longer distances for victims. Also, the arousal domain of the NAS showed significance in predicting travel. Arousal traits include having a high intensity reaction to situations, being angry for longer periods of time than normal, being more irritable, and being more tense (Novaco, 1994). The current study found that individuals with more traits defined by the arousal domain are less likely to travel for victim selection, or travel shorter distances.

Within the AQ, the verbal aggression factor was a significant predictor for distance traveled. This means that serial killers who possess more traits outlined by verbal aggression, are more likely to travel for victim selection than those with less traits of verbal aggression. The traits outlined by verbal aggression include verbally hurting or verbally harming someone (Buss and Perry, 1992). However, the other measures of the AQ, physical aggression, hostility, and physiological arousal were not predictors of distance traveled.

Implications

Although these findings may not be applicable to investigations to determine where a serial killer might live or where a serial killer might get his next victim, these findings still have some important implications within the field of investigations. Due to the cognitive and arousal factors of the NAS being significant predictors of distance, as well as the verbal aggression factor of the AQ, a personality profile of a serial killer can be created. This can be done by determining if he traveled for one of his victims or not. If the killer did travel for one victim, this means he has more verbal aggression traits from the AQ as well

as more cognitive traits from the NAS. By looking at these factors, it can be determined how this killer behaves. For example, if an individual scores high on the cognitive factor, it means he or she has high levels of attentional focus, suspicion, rumination, and hostile attitude (Novaco and Chemtob, 2002). Also, someone scoring high on the verbal aggression would be more likely to speak out when angered (Buss and Perry, 1992). The same can be said if the killer did not travel for one of his victims. This would mean the killer has more traits from the arousal domain of the NAS, meaning the individual would have high levels of anger intensity, duration, tension, and irritability. Again, these traits can be used to determine how the serial killer typically behaves.

Limitations and Future Investigations

Although the results of this study can still be used during investigations, there are a few limitations that may have affected the results.

This study was not a controlled experiment. Because of this, there was no control group to compare the results to. Also, other variables, such as socioeconomic status, were not controlled for when determining how far the killer traveled.

The sample size used in this study was not a large sample. It was limited due to a couple factors; not getting IRB approval from multiple states, and limited information on serial killers.

Participants in this study all filled out self-reported anger and aggression measures. All of the participants in this study have been incarcerated for a period of time and so it is possible that the scores reported on these measures do not accurately represent levels of anger and aggression experienced while the participant was an active killer.

This study only used hostile aggression as a predictor for travel. Hostile aggression is defined as an impulsive reaction to anger with the intent to harm, (Gardner, Moore, & Dettore, 2014 and Bushman & Anderson, 2001). It is possible that other forms of aggression could be predictors of distance traveled.

The purpose of this study was to better understand why some serial killers travel for victim selection while other killers do not. Although anger and hostile aggression do not explain why serial killers travel, this is still an important topic as it can aid police investigations and help solve more cases. Future research could look at other factors that may

affect whether or not a serial killer travels for victims. One area that could be investigated is psychological disorders such as antisocial personality disorder which is commonly seen in serial killers, (Allely et al., 2014).

Another factor that could be examined to determine if it predicts distance traveled by serial killers is method of killing. This would involve looking at whether or not a weapon was used, what type of weapon was used, and if the weapon still required physical effort in order to kill the victim (such as strangling versus shooting a gun).

Other forms of aggression could also be used to determine if aggression plays a role. Although this study found that hostile aggression is not a good predictor, instrumental aggression could be. Also, as mentioned earlier, the participants in this study had all been incarcerated for a period of time before these measures were filled out. A study using measures collected immediately after a serial killer is arrested could be conducted to determine if hostile aggression is a predictor. This would allow for the measures to reflect how the killer felt while still active.

Conclusion

A serial killer is any individual who has killed two or more individuals on two or more separate occasions (Johns et al., 2008). Although not always, anger and aggression can be a factor in what leads an individual to take the life of another. With advancements in the understanding of crime scene analysis, levels of aggression can be interpreted from the murder crime scene. Because of this, this study looked at whether or not anger and aggression could be a predictor of how far a serial killer would travel for his victim. Through linear regressions, it was determined that the total STAXI, the total NAS, and the total AQ were not predictive of how far a serial killer would travel for distance. However, the cognitive and arousal factors within the NAS, as well as the verbal aggression factor in the AQ were significant predictors. Although anger and aggression overall do not significantly predict distance traveled, the information from this study can still be used during investigations to help build a profile of what behaviors the serial killer possess.

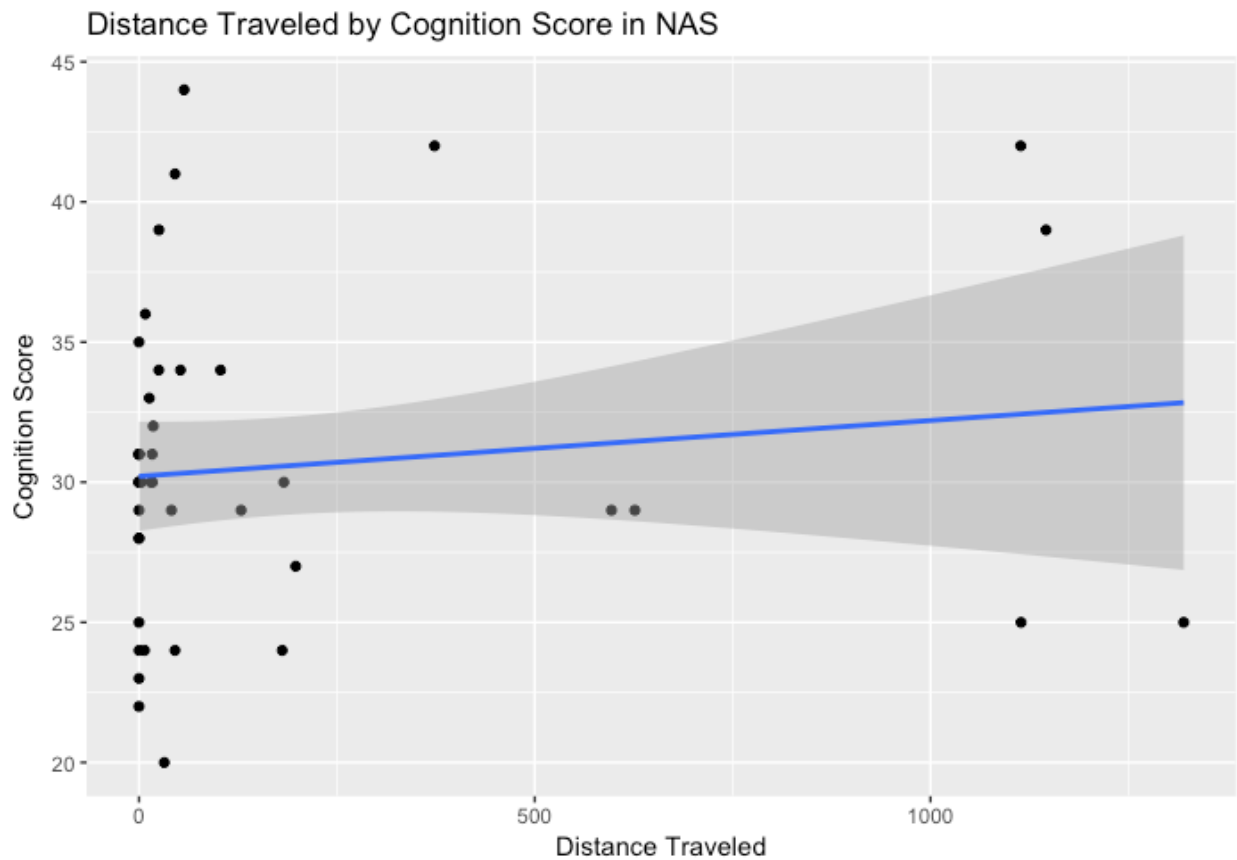


Figure 1: This figure represents the predicted distance traveled by a serial killer for victim selection with the cognitive factor from the NAS being used as the predictive variable. $\beta = 53.47$, $t = 2.98$, $p = 0.005$, The data points represent actual data points from the study. The blue line is a linear regression line, and the shaded area is the 95% confidence band.

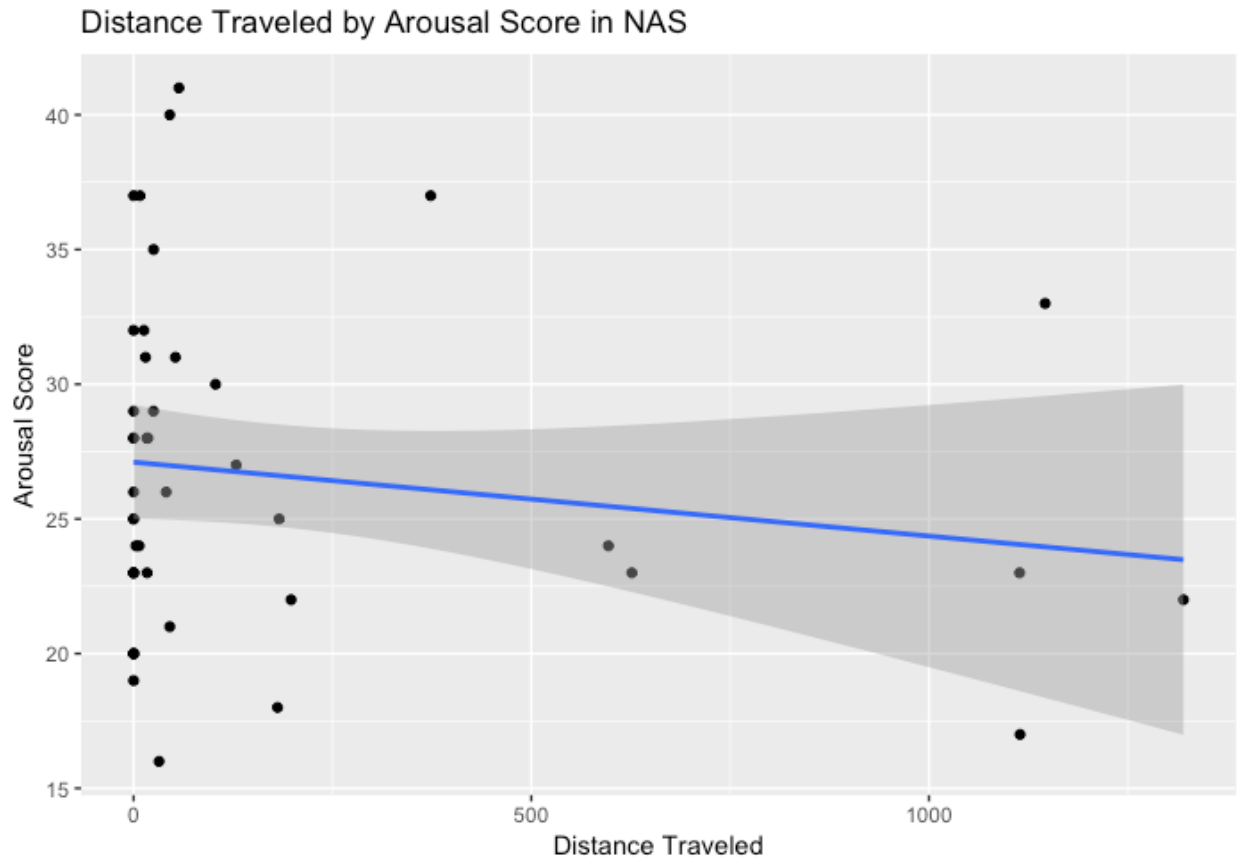


Figure 2: This figure represents the predicted distance traveled by a serial killer for victim selection with the arousal factor from the NAS being used as the predictive variable. $\beta = 39.60$, $t = -2.52$, $p = 0.02$, The data points represent actual data points from the study. The blue line is a linear regression line, and the shaded area is the 95% confidence band.

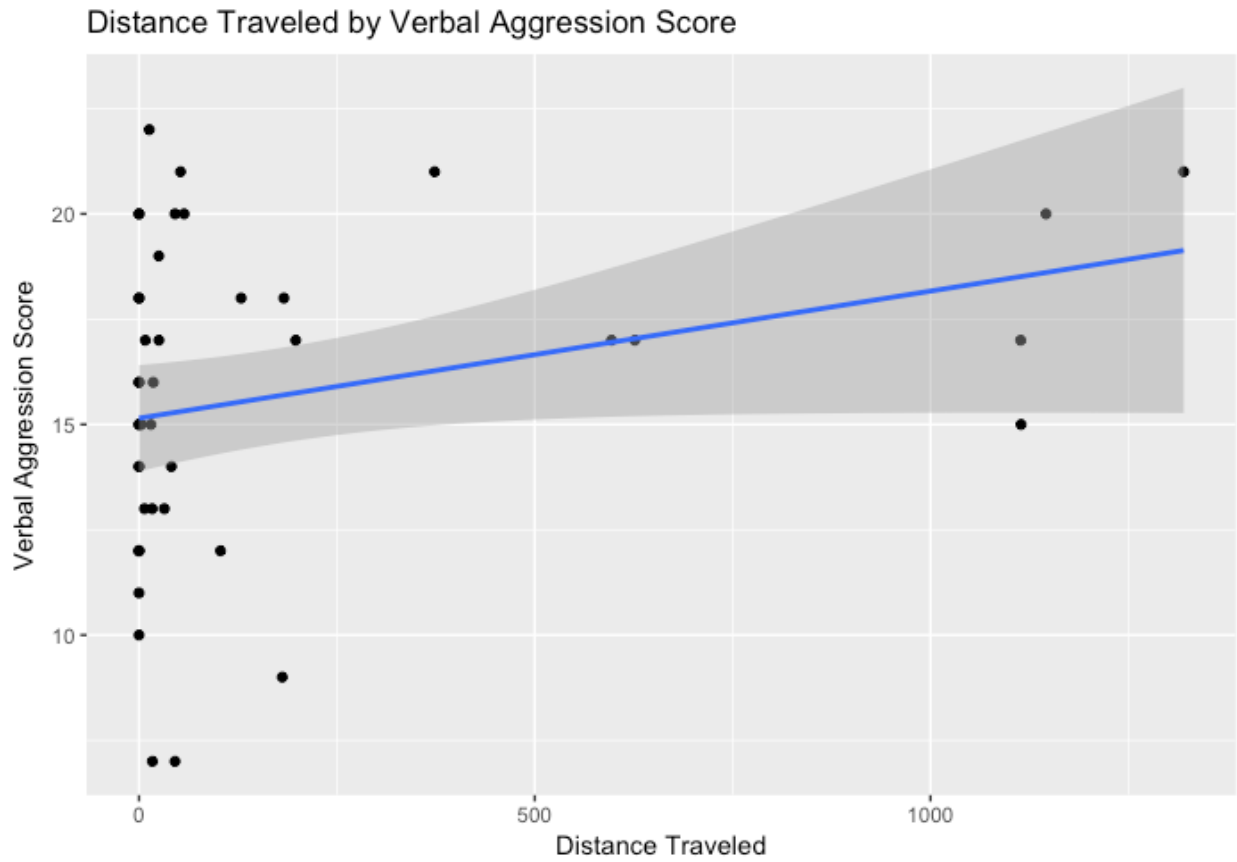


Figure 3: This figure represents the predicted distance traveled by a serial killer for victim selection with the verbal aggression factor from the AQ being used as the predictive variable. $\beta = 40.26$, $t = 2.18$, $p = 0.04$. The data points represent actual data points from the study. The blue line is a linear regression line, and the shaded area is the 95% confidence band.

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Research Topic: Nitrogenated Covalent
Organic Frameworks: A Two-Hole System

Introduction

This research is based upon finding an improvement for graphene, which is a two-dimensional single atomic layer of graphite; an abundant mineral and an allotrope of carbon that is made up of very tightly bonded carbon atoms organized into a hexagonal lattice. What makes graphene unique is its sp^2 hybridization and nanoscopic atomic thickness (of 0.345nm)⁷. This gives rise to a variety of applications of the material, and its derivatives. Since its isolation in 2004 graphene has culminated over 20,000 patents in different material applications. However, graphene has limitations; as it is not the transformational material most would suggest. Graphene falls short in four major arenas that are critical to expanding its applications, it has: limited functionalization, random pores "defects", pore size inconsistency, and pore homogeneity "chemical sameness".

To improve upon the limitations of graphene, covalent organic frameworks (COFs) have come to the forefront of interest. COF structures incorporate other light elements into their framework, such as hydrogen, boron, nitrogen, carbon, and oxygen. We utilize synthetic pathways with nitrogen that yields a stronger bond within the framework due to a greater difference in electronegativity. However, it also maintains aromaticity throughout the framework because of nitrogen's unique chemical characteristics. Incorporating nitrogen gives us much greater control over the order of the structure of our polymer as well as improves upon the chemical framework itself, creating a thinner material than even graphene⁷. The methods to produce these nitrogenated polymers are explored through different synthetic pathways, which give a polymer with ordered pores and modifiable attributes. The main reaction pathway for these syntheses is the condensation reaction between a carbonyl functional group and amines. This pathway greatly decreases the number of steps required in many COF synthetic methods, while inserting nitrogen into a highly ordered framework.

Methods

Utilizing the condensation reaction synthetic pathway between Hexaketocyclohexane (HKH)⁶ and 1,2-Diamino-Di-(NP) controlled molecular self-assembly was accomplished after a cross coupling reaction (scheme 1). The first condensation reaction between HKH and Diamino-Di-NP (DDNP – any protected diamino compound) undergoes an acid catalyzed mechanism by refluxing in glacial acetic acid/ethanol. Following the condensation reaction, the Hexaimine-Hexa-NP(3) undergoes a cross-coupling with 3,6-Dibromo-9,10-phenanthrenequinone(4) which adds carbonyl groups within the molecule for later self-assembly. An additional benefit to cross-coupling is the ability to add in different structures to precursors of the polymer to change the size of the pores, which yields ordered heterogeneity of pores (pore A versus pore B displayed in scheme 1). Following the coupling reaction, the protected nitrogen group (NP) can be deprotected to yield a structure that can react with itself through another dehydration process – self-assembly. This pathway will solve the major problems of graphene's structure. It gives access to an array of functionalization options, ordered pores, and manipulation of those pore sizes and chemical environments. These environments can be altered with simple reactions such as adding in metals to one sized pore to create optimal separation conditions.

Results and Discussion

Though the condensation reaction is relatively simple, finding the proper conditions that exist to give the highest efficacy of yield and least side reactions is challenging. Other methods found in literature report good yields, however, their methods are not shown to be reliably reproducible in practice. Side reactions such as 1D polymers are the biggest concern with other 2D COF syntheses. The advantage to the two-hole system is the removal of such defects that can occur with other 2D COF synthesis methods. The key step is the coupling reaction which removes the possibility of linear nucleation and allows the polymer to self-assemble. The synthesized two-hole COF polymer is characterized by transmission electron microscopy shows a promising lamellar structure and moiré pattern (figure 1).

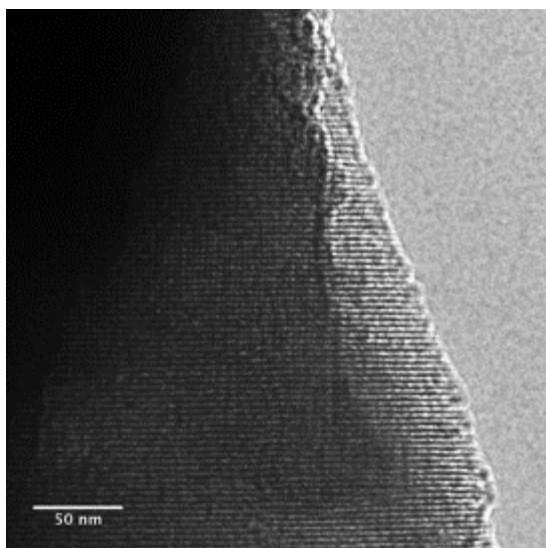


Figure 1. TEM of NCOF-2HS polymer. Hoberg group 2016.

Experimental Design

Materials and Equipment. Starting reagents were purchased from commercial suppliers (Sigma Aldrich and Fisher Scientific). NMR was carried out on Bruker Avance III 400 MHz series instrument. TEM data was acquired from FEI Tecnai G2 F20 S-Twin series instrument.

Hexaketocyclohexane-Octahydrate(1). Compound was synthesized according to literature methods⁴.

1,2-Ditosylamidobenzene. Compound was synthesized according to literature methods⁸. Further purification was required after following literature protocol. Toluene was added to the orange solution and concentrated under vacuo to give an orange solid. The solid was then recrystallized in ethanol to give a light pink solid. H- NMR performed in DMSO was consistent with known data. Solid was used as reagent for the following procedure.

1,2-Dinitro-4,5-ditosylamidobenzene. Compound was synthesized according to literature methods⁸.

1,2-Dinitro-4,5-phenylenediamine(2). The named compound was synthesized according to modified literature methods⁹. The 1,2-dinitro-4,5-ditosylamidobenzene solid (1.86 g, 3.67 mmol) was added to a round-bottom flask with concentrated sulfuric acid (5 mL). The solution was stirred at 90°C for 4 hours in a hot oil bath. The solution was allowed to cool to room temperature, deionized water was added for hydrolysis (200 mL). Solution was neutralized with sodium carbonate. The red solid was subsequently vacuum filtered and recrystallized in 1:1 acetone/water yielding yellow-red crystals (0.581 g, 80%). ¹H NMR (400 MHz, DMSO, 295K), d=7.09 (s, 1H, H_{arom}), 6.10 (s, 2H, NH₂).

2,3,8,9,14,15-Hexanitro-5,6,11,12,17,18-hexaazatrinaphthlene(3). Compound was synthesized following modified literature methods¹. Solid 1,2-Dinitro-4,5-phenylenediamine (0.580 g, 2.9 mmol) and solid Hexaketocyclohexane octahydrate (0.257 g, 0.823 mmol) were refluxed in mixed glacial acetic acid (25 mL) and ethanol (38 mL) for 24 hours. The solution was then vacuum filtered and concentrated under vacuo. ¹H NMR (400 MHz, DMSO, 295K), d=7.56 (s, 1H, H_{arom}).

3,6-Dibromo-9,10-phenanthrenequinone(4). To a round-bottom flask was added solid 9,10-phenanthrenequinone (2.005 g, 9.61 mmol), benzoyl peroxide (0.116 g, 0.479 mmol) and nitrobenzene (12 mL). While stirring, bromine (6 mL) was carefully added. While condensing the solution stirred for 2 hours under tungsten lamp (200W) for photochemical activation, foil was placed on the opposite side of lamp for optimization. The solution was then allowed to cool to room temperature. Ethanol was added to crash out the desired solid and left over night. A yellow solid (3.34 g, 94%) was vacuum filtered then soxhlet extracted with ethanol to remove undesired impurities, bright yellow solid was recovered (2.52 g, 73%). ¹H NMR (400 MHz, DMSO, 295K), d=8.69 (s, 1H, H_{arom}), 7.94 (d, 1H, H_{arom}), 7.79 (d, 1H, H_{arom}).

2,3,8,9,14,15-Hexanitro-5,6,11,12,17,18-hexaazatrinaphthlene-triphenanthrenequinone(5). Compound was synthesized following general diarylation methods¹⁰. To a round-bottom flask with side-arm added solid 2,3,8,9,14,15-Hexanitro-5,6,11,12,17,18-hexaazatrinaphthlene (0.061 g, 0.0932 mmol), solid 3,6-Dibromo-9,10-phenanthrenequinone (0.135 g, 0.373 mmol), palladium acetate catalyst (0.002 g, 10 mol%), potassium acetate (0.055 g, 0.559 mmol), Ditertbutyl(methyl)phosphonium tetrafluoroborate (0.0023 g, 10 mol %), and Dimethyl acetamide (4 mL). The vessel was purged and reacted under argon atmosphere at reflux for 3 days. Solid was precipitated with deionized water and filtered with vacuum. The sample was subjected to soxhlet purification with methanol, water, and acetone:ethanol in subsequent order and then dried on a vacuum pump overnight.
NCOF-2HS.

Solid tri-coupled sample (5) (0.055 g, 0.043 mmol) was added to a parr reactor with dimethylacetamide solvent (10mL) and platinum oxide (0.002 g, 10 mol %). The reactor was pressurized to 85 psi with Hydrogen, then allowed to stir at room temperature overnight. The solution was then heated to 100°C and reacted for two more days.

Conclusion

Using small molecules as building blocks we can synthetically create covalent organic frameworks; useful because of their low mass densities, permanent porosity, and high thermal stability⁶. The nitrogenated compounds of interest can be synthesized via a simple condensation reaction in controlled conditions. The conditions for all the COF synthesis are best under thermodynamic control so that undesired intermediates can reach the desired structure⁶. Characterization of these materials is best done in XRD, TEM, STM, SEM; NMR and FTIR which can indicate framework structure depending on functional groups and side products. These frameworks are usually highly aromatic, thin, and resilient. The uses for these structures are vast; given the permanent porosity, with a defined sized and ordered structure. Post synthetic functionalization² is also a possibility to modify the structure, giving a variety of control over the structure and applications. These characteristics could be used in membranes for organic filtration, catalysis, among other applications; such as those proposed in gas storage, photonic, and catalytic materials³. Utilizing membrane technology that can be modified at will may be used to capture things like oxygen for separation, membranes are light and compact; scaling down the space devices take and energy required to use them. This particular method for synthesizing a two-hole framework is simple and cost-effective giving rise to the implication that it improves upon materials such as graphene and other one-hole covalent organic frameworks.

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Research Topic: The Potential of Hydrocarbons to Affect the Ability of KCL to stabilize Montmorillonite

Introduction

Clay swelling occurs when water interacts with a stable clay, which will take in water molecules into the interlayers and result in swelling (Aften, 1994). This characteristic of clay can potentially change the porosity of the hydrocarbon reservoir when hydraulically fracturing. Damage to equipment, formation, and well-bore instability will increase costs of production and can result in abandonment of the well (Anderson, 2009). Figure 1 shows the expansion of clays when subjected to water.

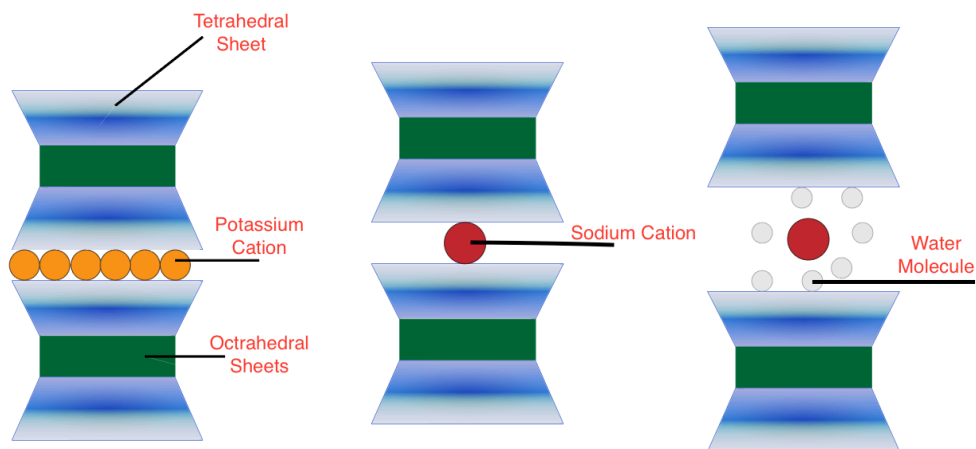


Figure 1 Schematic depicting an unexpansive clay (left), a dry expansive clay (middle), and a wet expansive clay (right)

Illite and smectite consist of aluminosilicate layers, with illite containing a greater net negative charge due to a substitution of Al for Si (Stixrude, 2002). The Na interlayer cation of Wyoming montmorillonite can be surrounded by water

molecules, represented by the chemical equation: $\text{Na}_{0.33}(\text{Al}_{1.67}\text{Si}_{3.67})\text{O}_{10}(\text{OH})_2 \cdot \text{H}_2\text{O}$ (Cosultchi, A., et al, 2005). Na is an exchangeable cation within the smectite, which controls the d-spacing of the clay when in solution (Aften, 1994). This means the composition of the aqueous solution the clay comes into contact with will control the amount of swelling (Amorim et al., 2007).

There are two types of clay swelling: intracrystalline swelling, where there is a limited amount of water that is able to be absorbed, and osmotic swelling, which has an unlimited adsorption of water (Suter, 2011). Clays that surround hydrocarbon reservoirs typically undergo osmotic swelling (Cosultchi, A., et al, 2005). The occurrence of clay swelling can be reduced through cation exchange (Amorim et al., 2007).

Smectite to smectite-illite is favored by a combination of high temperature, high pressure, high liquid to solid ratio, and the dioctahedral structure of smectite; furthermore the amount of illite formed is influenced on concentration of K in the system (Ferrage, et al., 2011). This study will analyze the partial cation exchange between smectite and a K-surface fluid, focusing on how hydrocarbons affect the exchange with different concentrations of K.

Method

Clay samples used in this experiment are from the SWy-2 area, processed by Purdue University. A total of 34 grams of clay were placed in an oven at 90 degrees Celsius with the purpose of drying out the clay. This sample is then distributed into two separate containers, container 1 for a clay + surface fluid interaction and container 2 for a clay + hydrocarbon + surface fluid interaction. The process of hydrocarbon extraction is conducted using an Accelerated Solvent Extractor (ACE). The hydrocarbon in an acid solution is then placed in container 2 and both containers are placed under a hood to allow the acid from contain 2 to evaporate.

Containers one and two are then placed in a humid-free glass box while the surface fluid is mixed. This process uses deionized water, Calcium Chloride, Sodium Chloride, Sodium Sulfate, Hydrochloric Acid, and Methanol. The 1 liter fluid is then divided into two vessels, where one solution will contain 0.4 M KCl while the other vessel will have 2.2 M KCl. Each vessel contains enough water to use the same fluid in two clay samples.

Approximately 8 grams of clay sample are placed in separate Titanium Oxide (TiO_2) vessels, referred to as bags when pertaining to content. Bag 1 contains 8 grams of clay and is then filled to full volume with 0.4 M KCl. Bag 2 contains clay sample and is filled to full volume with 2.2 M KCl. Bag 3 contains clay sample with approximately 0.5 gram hydrocarbons and fluid containing 0.4 M KCl. Bag 4 contains clay sample

with approximately 0.5 gram hydrocarbons and fluid containing 2.2 M KCl.

All bags are then placed in a low-temperature oven at 30 degrees Celsius for 28 days. This time is determined using the average use time from a hydraulically fractured well (Lan, 2014). The clay samples are then analyzed using X-Ray Diffraction, Inductively Coupled Plasma-OES, and SEM.

Graphs of Results

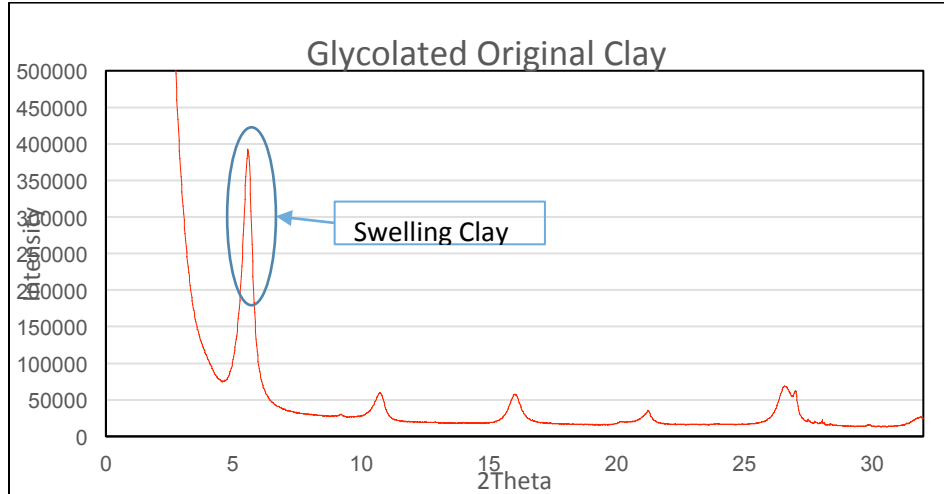


Figure 2 XRD results, original clay that was not exposed to water

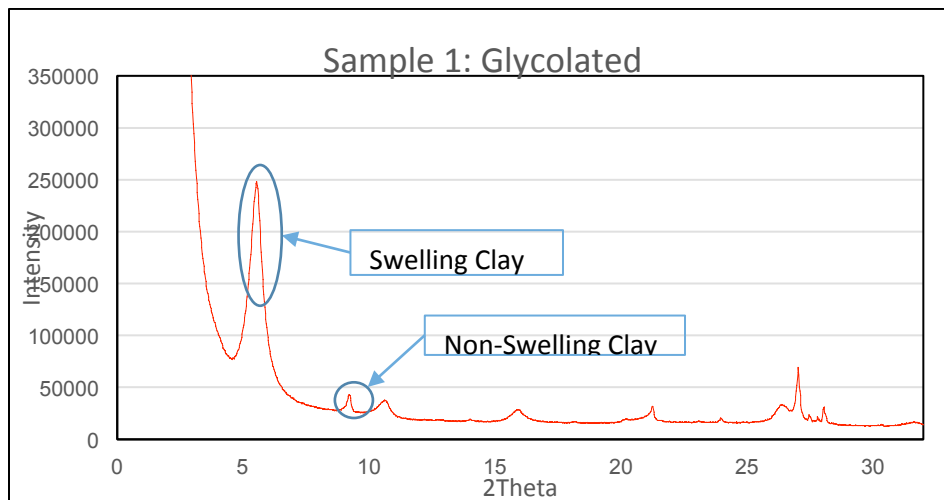


Figure 3 XRD results, sample 1 containing 0.4 M KCl

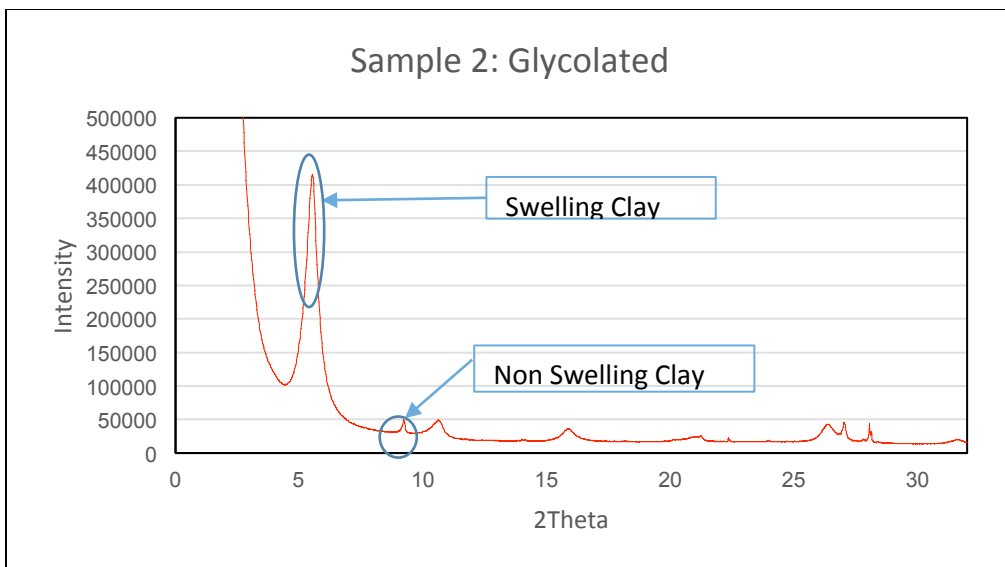


Figure 4 XRD results, sample 2 containing 2.2 M KCl

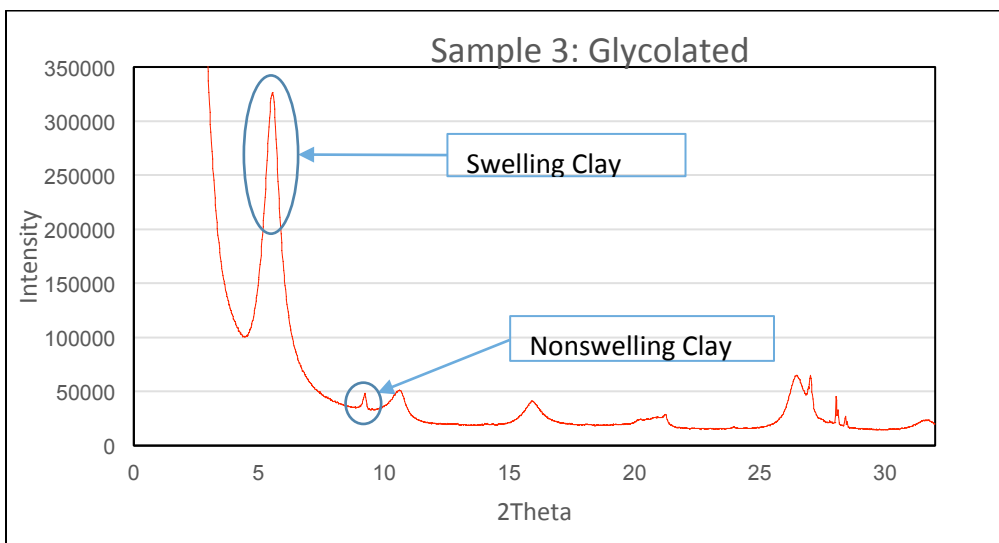


Figure 5 XRD results, sample 3 containing 0.4 M KCl and 0.5 grams hydrocarbons

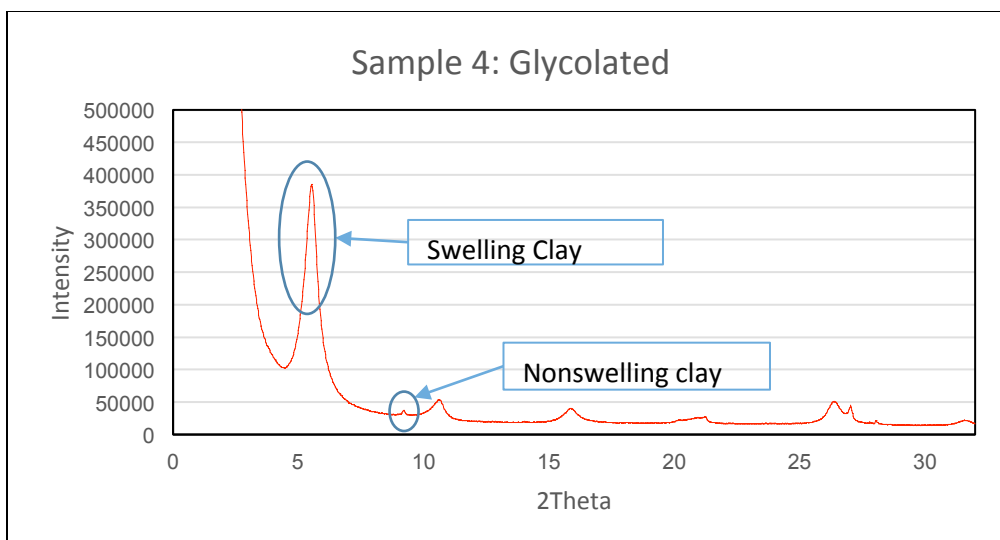


Figure 6 XRD results, sample 4 containing 2.2 M KCl and 0.5 grams hydrocarbons

Samples	Ca2+	Mg2+	K+	Na+	Si4+	Cl-	CB	pH
Original	0.00037427	4.11353E-05	-0.0273669	0.03292736	-0.0002848			1.83
0.4 M	0.00022456	4.11353E-05	3.45027789	0.04258373	-0.0002136			1.71
2.2 M	7.4854E-05	8.22707E-05	16.4252666	0.04284472	-0.0001424			1.48
Sample 1	0.10494536	0.045043192	2.64717392	0.13357982	0.02189742			2.32
Sample 2	0.11527521	0.054792267	13.5990567	0.19482384	0.01313845			2.57
Sample 3	0.11634812	0.05281777	2.82876749	0.169291	0.02043759			2.44
Sample 4	0.08391137	0.042369395	13.4814046	0.17468465	0.00907942			1.94

Figure 7 ICP results, pH, and charge balance

Results Discussion

XRD results show a decrease in swelling compared to the original clay, while the presence of non-swelling clay increases. However, Sample 1 has a higher intensity of non-swelling clay compared to Sample 3, which contained hydrocarbons. Samples 2 and 4 show less intensity of non-swelling clay compared to Samples 1 and 3, however sample 4 has less intensity compared to Sample 2. Results from ICP-OES show an increase in Na⁺ into to fluid after the interaction between surface fluid and clay took place, whereas K⁺ decreased after this interaction. This is an indication of cation exchange.

Next steps for this experiment include an analysis of anions in the fluid, calculations in XRD, and a base experiment. Analyzing anions in the surface fluid before and after exposure to clay will determine the role Cl⁻ undertook. The ICP-OES results show a change in concentrations of the cations K and Na; however if Cl⁻ is constant in both before and after fluids then it can be said that the K in KCl went into the clay interlayers replacing Na, thus creating NaCl in

the fluid. If Cl^- is not constant, then further tests will need to be performed to figure out what role Cl^- is contributing to the fluid + clay interaction.

Another step will be to use Bragg's Law to calculate a quantitative change in d-spacing of each sample. Figure 8 represents how Bragg's Law can be applied to the interlayers of clay. Lambda is determined by the wavelength of the x-ray,

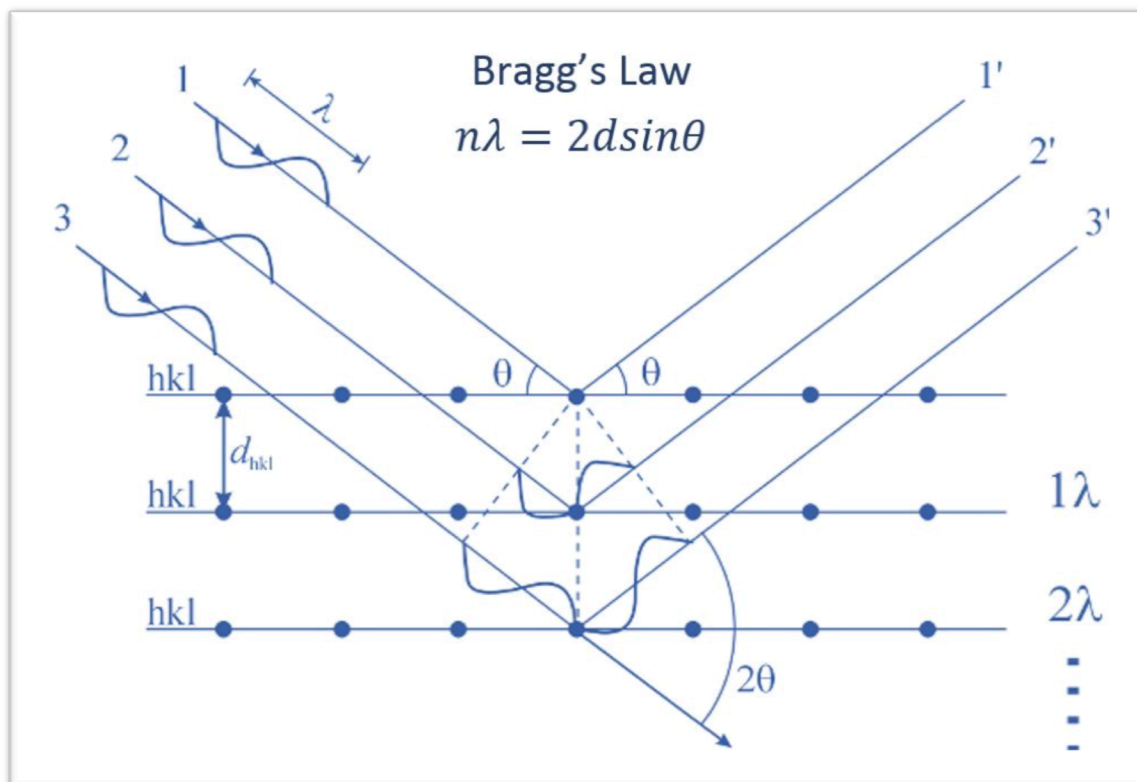


Figure 8 Schematic of Bragg's Law used to calculate the d-spacing between interlayers of clay

theta is determined by the clay particle which is also represented on the graph in results. The d represents d-spacing between interlayers, while hkl are the T-O structures represents in figure 1. By rearranging this equation, a quantitative d-spacing can be determined.

Finally, a 5th sample will be set up and used as a blank. Using the original fluid, which had no KCl added to it and the same sample of clay I will be able to analyze how the KCl affective each sample, along with what consequences the hydrocarbons had on clay stabilization. This base will fill multiple holes in my experiment. By being able to compare each sample to a clay that was exposed to just surface water, it contributes a quantitative value to clay stabilizers.

Conclusion

Swelling clays are a costly phenomenon in the oil and gas industry. By analyzing the reaction between fluid and clay

with different concentrations of KCl and the presence of hydrocarbons, the effectiveness of clay stabilizers will be quantifiable. An understanding of how clays react to clay stabilizers in fluid is an important study for justifying concentrations of KCl in the fluid. If smaller concentrations of KCl can be added to the surface fluid and be as effective, it is economically and environmentally beneficial.

Results from XRD, ICP-OES indicate the hydrocarbons hindered cation exchange in the 0.4M fluid while they did not affect the 2.2 M surface fluid to the same extent. Further tests and experiments will be conducted in order to conclude the results of this experiment. This includes, using anion results to verify a cation exchange between K and Na, using Bragg's Law to quantify the change in d-spacing between samples, and a blank experiment to compare the results of the previous experiment.

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Research Topic: Bacterial Cellulose: A Consumer Market Evaluation

Introduction

As the textile industry balloons towards increasingly unstable practices to meet demand, consumer textile waste rests among the top concerns in the industry. The year 2012 signified a breaking point of sorts for this industry when the EPA reported that textile waste accounted for 9% of all consumer solid waste (EPA, 2012). In the wake of this report, the global community has responded with a concerted effort to investigate sustainable alternatives to common textiles; to date, a handful have been noted. One such textile alternative is bacterial cellulose, a web of micro-cellulose fibers produced by a small acetic-acid bacterium well-known in the field of applied microbiology.

Bacterial cellulose is easily dichotomized from traditional cellulosic fibers in that the product is biodegradable and highly inert, culminating in a non-woven textile that resembles vegetable leather. Moreover, bacterial cellulose is markedly different from traditional cellulosic fibers to the extent that it lacks hemicellulose and lignin; that is, the material is composed solely of micro-cellulose fibrils produced and extruded by *Komagataeibacter xylinus*' transmembrane enzyme cellulose synthase. Lacking hemicellulose and lignin, the cellulosic micro-fibrils interact extensively with one another via hydrogen bonds at the 3' hydroxyl groups. Indeed, these interactions make for a highly crystalline, absorbent, and strong fiber-web.

Of course, investigations into the properties of bacterial cellulose hold promise for a greener fashion industry; yet, the properties of bacterial cellulose, no matter how favorable, are moot if consumer interest is not garnered by the product. As a matter of necessity, this study

intends to discern consumer perceptions of bacterial cellulose as it relates to other textiles. Ultimately, the results of this study will be used in tandem with traditional laboratory techniques to further modulate bacterial cellulose according to consumer tastes.

Marketing research involves exploring the honest views and opinions of consumers to produce or improve products. To achieve the advantages of marketing research, researchers must recognize the research process and its restrictions. Bacterial cellulose is considered a new market to consumers and the marketing industry and therefore requires basic marketing research. Basic marketing research does not address the desires of specific organizations (Babin and Zikmund, 2016). Rather, it is used to expand knowledge about a market or marketing phenomena (Babin and Zikmund, 2016). This form of research is not intended to solve a problem, but it is used to simply identify foundational information about markets (Babin and Zikmund, 2016). Bacterial cellulose marketing research requires exploratory basic research to form further investigations and to guide the possible manipulation of textile characteristics to meet the needs and wants of consumers.

Previous explorations into cellulosic textiles – cotton in particular – have yielded a foundation in consumer perspectives. Using a seven-point semantic scale, Schutz investigated four dimensions of cotton and other textiles: desirable characteristics, problem areas, fragility, and summer-wear potential (Schutz, 1976). This inquiry demonstrated variance in consumer perceptions as a function of weaves, indicating that the structure and finish of the textile profoundly impacts consumer beliefs relating to cellulosic textiles. Nonetheless, certain trends in perception reports remained stable regardless of differences in the weave. For example, Schutz noted that consumers perceived all cotton weaves to be comfortable, fire resistant, easily cared for, and durable. To this end, we anticipate bacterial cellulose to garner similar responses to these conserved perceptions.

Another aspect to consider for this research is new-product adoption behaviors of consumers. Bacterial cellulose is an innovative textile meaning consumers have not been exposed to this product, which opens up the possibility for innate consumer innovativeness (Im, Bayus, & Mason, 2003). Innate consumer innovativeness drives consumers to become

adopters of products (Im, Bayus, & Mason, 2003). Innovativeness is based on characteristics of the consumer. Characteristics that cause consumers to become adopters of products include income, education level, age, social participation, and level of risk taking (Im, Bayus, & Mason, 2003). Product adopters tend to be higher earners, educated, young, social leaders, and risk takers (Im, Bayus, & Mason, 2003). Through our research, our demographic data will help provide insights into product adoption based on income, age, gender, religious ideology, and political affiliation. Further driving forces behind consumer product adoption include innovation diffusion (Peres, Muller, & Mahajan, 2010). Essentially, innovation diffusion is consumer signaling, which is effected by internal forces (characteristics of the consumer), diffusion of technologies (social networks, network externalities, takeoffs and saddles and technology generations), and diffusion of markets (cross country, growth of countries, and competition) (Peres, Muller, & Mahajan, 2010). These diffusions act as signals to the consumer, which causes consumers to adopt products. An example of such signaling can be seen when Blockbuster began carrying large amounts of DVDs compared to VHS tapes (Peres, Muller, & Mahajan, 2010). This sent a signal to consumer through technology diffusion signaling that DVDs would be replacing VHS tapes and therefore drove the replacement of older technology (Peres, Muller, & Mahajan, 2010). In terms of bacterial cellulose, the diffusion of sustainability will be the primary signal for consumer adoption. Due to the lack of consumer knowledge about bacterial cellulose, it can be assumed that there are fewer consumer signals and diffusion affecting consumer perceptions of this product and therefore consumers may not adopt this textile in the current market.

This study was aimed towards examining consumer perspectives of bacterial cellulose's textile characteristics and preferences for end uses. To reveal consumer perspectives of bacterial cellulose our research team gathered questions pertaining to the sensibility of the material based on a similar study relating to bast fibers (Ju, Jin & Cho 2016). Sensibility and perceptions of the textile are required to clarify sensory information of consumers based on esthetics and emotional factors. Understanding consumer opinions of fabrics is critical for manufacturers and designers in the development of products (Ellis & Garnsworthy, [1980](#)). Consumers use multisensory approaches to evaluate textiles such as

touch, vision, smell, audition, and taste; these multisensory perceptions have a substantial impact on consumers' satisfaction of the textile. (Schifferstein, 2006). Moreover, consumers' sensibilities are subject to fiber content; for example, silk is perceived as luxurious and expensive, cotton is perceived as comfortable, and polyester is perceived as practical (Forsythe & Thomas, 1989). Due to bacterial cellulose being a novel textile, we aimed to collect the general sensibility dimensions of the material through the consumer survey as well as other basic perceptions to determine the material's likeliness of market acceptance. Exploring the research gaps identified above, this study proposes the following research questions:

Research Question 1: What are possible end-uses for bacterial cellulose in the textile industry?

Research Question 2: What are possible products consumers will be interested in buying made out of bacterial cellulose?

Research Question 3: Who is the ultimate consumer for bacterial cellulose?

Predictions

Prediction Research Question 1- Since bacterial cellulose represents vegetable leather, most consumer determined end-uses will mirror those of leather.

Prediction Research Question 2- Bacterial cellulose is very similar to vegetable leather, so consumers may be interested in buying products that are usually made out of leather (luggage, bags, and various accessory items).

Prediction Research Question 3- Since bacterial cellulose is a sustainable textile and currently has a high production cost the ultimate consumer of bacterial cellulose is an individual interested in sustainability and is willing to pay more for sustainable products.

Research Methods

In designing the questionnaire to be used in this study, careful consideration was given to the Marketing Research Society (MRS) Code of Conduct, the charter governing market research. In particular, we ensured that all those who participated in the survey were 18 years of age or older (Mouncey, 2010). Our age limit was set with three purposes: most ostensibly, the limit protects respondents, reduces the need for visual marketing techniques in designing the survey,

and ensures an age group with disposable income to purchase the textile (Shin Rohani, 2014).

After securing IRB approval, the survey was administered to 20 participants to guarantee sufficient power for analysis. To develop a sample representative of the greater population and prevent artificial homogeneity, we elected to forego the convenient student population available to us for a more robust referral method (Espinoza, 2016). Data collected fell under three levels of measurement: ordinal, nominal, and open-ended-description. Ordinal data was analyzed using the median response, nominal data was reported by way of the mode, and open-ended responses were reported for qualitative insights. Our P-value for the Friedman test was set at the conventional .05, but was also examined relative to a more conservative P-value of .1.

As Marketing Insights Council (MIC) president Matt Valle notes, "modern marketing research is deeply rooted in behavioral economics, a field devoted to understanding consumer behavior," (Valle, 2013). Modern marketing techniques are, therefore, diverse and highly digital in nature, aiming to take advantage of globalization (Valle, 2013). Russell Belk, on the other hand, highlights the tendency of consumer behavior to be highly contingent on culture and broadly influenced by societal values (Belk, 2015). It is this contingency on culture and experience that makes adjusting for confounders increasingly important. Certainly, income, age, and gender are profound predictors of consumer behavior(s); therefore, we elected to adjust for all three variables to overcome the effects of societal segmentation in terms of data evaluation (Belk, 2015).

Our survey was carefully constructed to understand consumer characteristics of those who are interested in bacterial cellulose as a textile. The survey revealed key characteristics of potential consumers of bacterial cellulose and their overall interest in bacterial cellulose as a textile. The survey collected demographic information such as age, gender, and income. Other characteristic information was also solicited such as willingness to pay more for sustainable products. Additionally, the survey examined willingness to choose bacterial cellulose over various traditional textiles (cotton, leather, linen, and rayon), perceptions of the value of bacterial cellulose, perceptions of the textile hand and aesthetic, consumer interests in various end-uses of bacterial cellulose, and more.

Results

Analyses focus on the 20 participants' consumer perception of bacterial cellulose as it relates to the textile industry. Bacterial cellulose is a sustainable textile alternative to leather and other cellulosic textiles; however, to reduce biases within the survey bacterial cellulose was described only as a cellulosic material. Other characteristics such as biodegradability, sustainability, self-healing characteristics, and so on were not detailed in the survey to ensure consumer perceptions were solely based on bacterial cellulose as a textile. Current operation costs for bacterial cellulose are relatively high compared to other cellulosic materials and even some leathers, which is why the survey begins with a question pertaining to spending more on sustainable apparel products. All participants were willing to spend more on suitable apparel products; 20% were willing to spend 1-10% more, 25% were willing to spend 11-20% more, 20% were willing to spend 21-30% more, 5% were willing to spend 31-40%, 15% were willing to spend 41-50% more, 5% were willing to spend 61-70% more, 5% were willing to spend 71-80% more, and 5% were willing to spend over 100% more on sustainable apparel.

Basic aesthetic and hand qualities were also questioned for bacterial cellulose including comfort, care, durability, style relevance, practicality, and so on. 50% of participants ranked the material as being uncomfortable, 35% ranked the material as comfortable, and 15% of participants ranked the material as neither comfortable nor uncomfortable. 40% of participants viewed the material as being hard to care for, 45% viewed the material as easy to care for, and 15% of participants viewed the material as being neither easy nor hard to care for. As for durability, 50% of consumers believed bacterial cellulose was durable, 45% believed the material was delicate, and 5% of consumers thought the material was neither durable nor delicate. 45% of consumers thought bacterial cellulose was relevant to current textile styles, 10% thought the material was out-of-date, and 45% thought the material was an updated style. 85% of participants perceive bacterial cellulose as urban, 5% perceive it as rural, and 10% perceive the material as neither urban nor rural. 60% of participants identified bacterial cellulose as being artificial, 30% identified the material as natural in appearance, and 10% of participants identified the material as neither artificial nor natural. In regards to how cheap or expensive the material

appears to be, the consumers were moderately split. 40% of consumers thought the textile was expensive, 35% thought the textile was cheap, and 25% of consumers thought the material was neither expensive nor cheap. 45% of participants classified the material as practical, 30% classified the material as decorative, and 25% of the participants classified the material as neither practical nor decorative. The majority of consumers viewed the material as casual and neither feminine nor masculine as well.

After key characteristics of the material were analyzed, purchasing insights were examined. In order for bacterial cellulose to be a textile alternative to leather and other cellulosic materials, consumers must be interested in purchasing the material over such materials. Participants were asked to rank their likeliness of purchasing bacterial cellulose as an apparel product, home furnishing product, and accessory product as well as their likeliness to purchase those products over leather and other cellulosic materials. 30% of consumers are not interested in purchasing the material as an apparel product, 60% are interested, and 10% are neither interested nor uninterested in purchasing this material as an apparel product. As for home furnishing products made from this material, 10% are not interested in purchasing a home furnishing product made out of bacterial cellulose, 65% are interested in purchasing bacterial cellulose home furnishing products, and 25% are neither interested nor uninterested. 75% of participants were interested in purchasing an accessory product made from bacterial cellulose and 25% were neither interested nor uninterested in accessory products made from bacterial cellulose. 45% of consumers were unlikely to use bacterial cellulose over leather for accessory products, 40% were likely to use the material over leather for accessory products, and 15% were neither likely nor unlikely. 50% of participants were unlikely to use the material over leather for home furnishing products, 45% of participants were likely to use the material over leather for home furnishing products, and 5% neither unlikely nor likely. 60% of consumers are likely to use bacterial cellulose over leather for an apparel product, 35% were unlikely, and 5% were neither likely nor unlikely. 50% of participants were likely to use this material over other cellulosic textiles (cotton, linen, and rayon) for accessory products, 35% were unlikely, and 15% were neither likely nor unlikely. 40% of consumers were likely to use bacterial cellulose over other cellulosic material for home

furnishing products, 30% were unlikely to use it as an alternative, and 30% were neither likely nor unlikely. 35% of participants were likely to use the material as an accessory product over other cellulosic materials, 45% are unlikely to use it over other cellulosic materials, and 20% were neither likely nor unlikely.

In addition to consumer willingness to use the material over traditional textiles, we examined potential end uses consumer expected to find the material composing via an open ended response. In terms of garments 44% of consumers expected to see the material used in the construction of jackets, 40% expected to see it used in the construction of shoes, 67% expected to see it used in the construction of chair upholstery, 46% expected it being used for curtains, and 56% of consumers believed the material could be used as a canvas material. 33% of consumers did not believe the material could be used as a shirt material, 42% did not view it as being used for shorts, pants, or skirts, 80% did not see it being used in the construction of couches, and 80% of consumers also did not see it being used as a paper product.

Discussion

Through this research we were able to determine possible end uses and consumer perceptions of bacterial cellulose. These finding will help further guide research into manipulating the textile into a product that will be adopted by consumers based on feedback provided by participants. Key findings include bacterial cellulose not currently being suitable for apparel products such as pants, skirts, shorts, and shirts as well as some home furnishing products such as couch upholstery. End uses that were favorable by consumers included jackets, shoes, canvas materials, curtains, and chair upholstery. Another desired end use for bacterial cellulose was for an accessory material for the construction of purses, wallets, luggage, and belts. Based on these initially results we also have determined that consumers are more interested in using bacterial cellulose as a leather alternative rather than a cellulosic (cotton, linen, and rayon) alternative. We anticipate these results will vary as we continue to improve the textile properties of this material (absorbency, texture, hand, and tensile strength).

In addition to end-use insights, our findings illustrated general perceptions of bacterial cellulose as a material. In particular, consumers perceived the material to be more

artificial than natural – a perception that may inhibit the material's adoption as a sustainable textile. Moreover, consumers believed the material to be an updated style with agreement that the material is urban as opposed to rural. Furthermore, the majority of respondents indicated that they believed the material to be uncomfortable, which speaks to the hand of the textile and showcases another potential barrier to adoption of this material as a textile alternative. Additionally, bacterial cellulose was characterized by respondents as practical as opposed to decorative; this trend speaks to consumer perceptions of the material's aesthetic and indicates that consumers see the material as being potentially useful. Finally, respondents classified the material as durable, which serves to highlight the potential that bacterial cellulose may have in high-stress end uses such as leatherette applications and upholstery.

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Research Topic: Microbial Succession vs Plant Developmental Effects on Rhizosphere Community Structure in *Arabidopsis thaliana*

Introduction

The rhizosphere, the microbial community in close physical proximity to the roots, is composed of diverse microbes, potentially including tens of thousands of different taxa. Numerous biotic and abiotic factors have been shown to affect microbial community assemblage (Lareen et al. 2016; Berg et al. 2009; de Vries et al. 2012). pH has been shown to be a main driver of rhizosphere structure (de Vries et al. 2012), but other abiotic factors include soil moisture (Brockett et al. 2012), soil texture in the form of silt percentage (de Vries et al. 2012), chemical composition like carbon and nitrogen levels (Eilers et al. 2010), precipitation (de Vries et al. 2012; Brockett et al. 2012), biogeography, and climate have been shown to influence the rhizosphere. Biotic factors that influence rhizosphere structure include the plant host species (Berg et al. 2009), plant genotype (Bodenhausen et al. 2014; Bulgarelli et al. 2013), microbe-microbe interactions (Bulgarelli et al. 2013; Gaiero et al. 2013), and plant-microbe interactions (Berg et al. 2009; Gaiero et al. 2013).

The main path by which plants interact with rhizosphere microbes is via root exudates which are chemicals released from the roots. Since microbes can perform many beneficial activities such as promoting plant growth (Hussain et al. 2016; Kielak et al. 2016), improving nutrient accessibility, and suppressing disease, it is useful for the plant to be able to select for beneficial microbes via root exudates. As the plant grows and develops, its needs change which can lead to a change in plant exudates. This means that at different developmental stages, different exudates are being released through the roots. This has led to the idea that the rhizosphere community structure might shift across a plant's development. Houlden et al. (2008) found that species of pea,

wheat, var, and sugar beet all selected for certain microbes, and they all had similar microbial compositions at the same developmental stage. Another study found that the exudates of *Arabidopsis thaliana* changed over development, and rhizosphere composition converged to similar communities at the end of the plants life (Micallef et al. 2009). Rasche et al. (2006) saw an effect of plant development on rhizosphere community structure, which was also seen in a study using *Arabidopsis thaliana* (chaparro et al. 2013). While these studies found interesting results, they either used outdated technologies or failed to account for the role of microbial succession in the different rhizosphere community structures.

Succession is the observed process of change of an ecological community over time. There are two distinct processes governing microbial succession, deterministic and stochastic processes (Dumbrell et al. 2010). Deterministic processes are ones where the relative abundance of a species is determined by biotic and abiotic factors (Dini-Andreote et al. 2015). Stochastic processes are ones where species abundance in a microbial community changes randomly regardless of species fitness, and also because of dispersal (Dini-Andreote et al. 2015). Another term synonymous to deterministic processes is niche processes (Nemergut et al. 2013). Liao et al. (2015) found that both niche and neutral processes affect microbial community assemblage. Stochastic processes (also known as drift) can potentially have a large effect on microbial community assembly because of the high number of taxa at low abundance (Nemergut et al. 2013).

The changes in microbial communities over a plants development could be due to the release of selective exudates through the roots, or it could be due to microbial succession. We designed a project that will allow us to determine if microbial succession or plant developmental stage is affecting rhizosphere community structure in *Arabidopsis thaliana*. We did this by selecting for mutants of the background Col, two that flower early because of a single gene mutation, and two that flower late because of a single gene mutation, and collecting at different time points. Collecting at each of the three flowering times (early, wild type, and late) will allow us to compare communities at both the same stage of development and different levels of succession, as well as communities at different stages of development but the same level of succession. We hypothesize that microbial succession is driving rhizosphere community structure, in which case we

will see different communities at each of the flowering times. Alternatively, plant developmental stage is driving the rhizosphere community structure, in which case we will see differences at a single time point of collection.

Methods

Experimental Design

We selected five genotypes of *Arabidopsis thaliana* background col, two early flowering genotypes, the wild type, and two late flowering genotypes. We selected this species of plant because it is a model organism and because its flowering time pathway has been extensively studied. The seeds were surface sterilized and then planted in a soil matrix that was 95% autoclaved potting soil and 5% soil inoculum collected from a location in Wyoming. The plants were grown in 4 growth chambers that were all set to 10 hour days, 21.1 °c, 40% humidity, and 100% light during the day. During the night, they were set to 15.5 °c, 40% humidity, and 0% light. The plants were arranged using a randomized complete block design.

The plants were exposed to water underneath the pots until they began germinating, and then we misted them every day until they were large enough to be watered. We collected at four different times, a month after planting when the plants were all vegetative, and then again when each of the genotypes flowered. The first collection was two weeks after germination on June 30th and 31st, 2017. The second collection was three weeks later on July 20th and 21st, 2017. The third collection occurred on August 15th, 2017, and the final collection took place 8 days later on August 23rd, 2017.

Sample Collection and Processing

We collected the rhizosphere samples by removing the plants from the pots, shaking off the bulk soil, and placing the roots in a sterile 50 mL falcon tube. 40 mL of 1x phosphate saline buffer was added to each tube and they were shaken on vortex machines for 15 minutes. Then the samples were passed through a steriflip filter that is a 100µm nylon mesh to separate the roots from the rhizosphere. This was to prevent the endophytes from changing the abundance or structure of the rhizosphere community. Then the tubes were spun down and the pellet transferred into a 2ml ependorph tube. This was done by adding 1000µl of the phosphate saline buffer, shaking the tubes, and then using a micropipette to uptake the sample and release it into the 2ml tube. Then the

tubes were flash frozen using liquid nitrogen and transferred to a -80 °c freezer for storage until DNA extraction. Once all four timepoints were collected, DNA was extracted from the samples using the DNeasy Powerlyzer Powersoil kit. We followed the directions given by the MO Bio Powerlyzer Powersoil kit handbook.

Data Analysis

The raw microbial sequence data was analyzed using Qiime, then data was analyzed using biomico which is a Bayesian model for comparing microbial communities for differences (Shafiei et al. 2015).

Results

Discussion

Many studies have looked at the effect of plant development and root exudates on rhizosphere community assemblage, but these studies fail to account for microbial assemblages. This study is not complete yet and is awaiting final data.

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