WHO ARE WE AND WHAT DO WE DO?

The Journal of Young Investigators (JYI) is an independent, non-profit, peer-reviewed, online science journal ran entirely by and for undergraduate students from across globe.

Recognizing the importance of science communication among scientists and with the general public, JYI believes that training in effective communication should be integral to science education. As the first international, hands-on attempt to provide such training for undergraduates, JYI is dedicated to involving undergraduates in every step of the writing, editing, and peer-review processes and to publishing only undergraduate research and science feature articles.

We believe that introducing undergraduate students to the process of peer-review, as an author and/or an editor, will give them a great deal of experience which will be beneficial to them in their future careers as scientists.

JYI’s mission complements current higher education initiatives that aim to make students’ science education more experiential and research-oriented. JYI addresses the remainder of the research process: communicating one’s research, reviewing and being reviewed by peers, writing about science for the general public, and other aspects of publishing and disseminating scientific information.

JYI publishes research and review articles in the biological & biomedical sciences, physical sciences & mathematics, engineering & applied sciences, and psychology & social sciences. Additionally, all published news and feature articles must also involve these fields in some manner.

From research editors to journalists and layout designers, JYI has a lot of great opportunities for science undergraduate students. For more information about us and our available positions, check out our website here: https://www.jyi.org.
Letter from the Editor

Dear Colleagues,

The Journal of Young Investigators was started with a particular goal in mind: to highlight the work of undergraduate students. Now, it is 2018, and JYI has been committed to this goal for 20 years. Through consistent quality research, news, and career publications, we have given undergraduates a platform to share their work with a larger academic audience - one that was previously inaccessible. We feel honored that we have been able to help undergraduates become acknowledged for their research efforts, and we are proud to be continuing this work.

JYI is a journal that is run entirely by volunteers. This is a testament to the passion and commitment of the members of JYI, who are motivated entirely by a passion for their work and an excitement for the unique experience they are gaining through JYI. Our staff members are from all across the world, giving the journal a uniquely broad perspective. We have a broad range of specializations as well, from financial experts to undergraduate leaders in research to communication specialists. JYI is a fully functioning organization, and we therefore need staff members to do all sorts of work to keep the organization running. Thankfully, we have an excellent staff that is not only maintaining the pristine state of the journal, but also excelling in their work.

At JYI, we are constantly aspiring to move the journal forward. As a remote organization, we are always striving to foster a strong sense of community among the members. In the near future we hope to be indexed, so that we can be among the ranks of professional journals. We are always trying to expand our reach by promoting the journal to many audiences, presenting at conferences, and networking with other science communities.

I am very pleased to share with you this issue of the Best of JYI. It showcases the best work of 2017 and I hope you enjoy it! If you would like to see more, you can go to JYI.org to see the latest issues and or even to get involved. We have many types of positions available - from science journalists to programmers to communications officers. You can also like our Facebook and follow us on Twitter to get the latest updates from JYI.

Best,
Jacquelyn Cobb
Editor-in-Chief, Journal of Young Investigators
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Correlations Between Gray-White Matter Contrast in Prefrontal Lobe Regions and Cognitive Set-Shifting in Healthy Adults

Carl Kim*, Thomas Thesen1, Lena Woo1

Humans have a unique capacity for higher order cognition such as planning and multitasking. These abilities are collectively referred to as executive functions. This study investigates cognitive set-shifting, a type of executive function that involves shifting from one task to another. Advances in neuroimaging have allowed for the structural integrity of specific frontal lobe subregions to be probed with greater resolution. One such measure is the intensity contrast between cortical gray and white matter, with greater contrast indicating better development. This study tested whether the gray-white matter contrast (GWC) in eight subregions of the prefrontal cortex (PFC) was associated with set-shifting abilities in 61 healthy participants. Set-shifting abilities were measured using two neuropsychology tests: Trail Making Test B (TMT-B) and Wisconsin Card Sorting Test-Perseverative Errors (WCST-PE), with a third test, the Boston Naming Test (BNT), used to determine the discriminant validity of set-shifting findings. Cognitive set shifting was significantly correlated with GWC in the left ventrolateral PFC (Broca’s area), the left and right middle frontal gyri (dorsolateral PFC), and the left and right superior frontal gyri. These findings indicate that successful set shifting relies on the structural integrity of ventrolateral and dorsolateral PFC, but not the basal orbitofrontal regions.

INTRODUCTION

Executive functions are a set of cognitive processes essential in organizing and monitoring behaviors conducive to the attainment of a goal. There are three core executive functions: working memory (short term memory that is manipulated), response inhibition (self-control) and cognitive flexibility (the ability to think about multiple concepts simultaneously) (Miyake et al., 2000). Some of the basic executive functions, such as working memory and inhibitory control, can be observed early in infants. However, the development of more complex executive functions, including cognitive flexibility (also referred to as “cognitive set shifting”), is what allows adults to complete challenging tasks. Many of these occupational tasks are coordinated and completed in the prefrontal cortex (PFC) (Miskin et al., 2015).

Structurally, the PFC consists of both gray and white matter. Gray matter is mainly comprised of cell bodies, dendrites and unmyelinated axons (Budday et al., 2015). It enables muscle movement by directing motor stimuli to neurons in the central nervous system (CNS) and contains glial cells (astrocytes, oligodendrocytes, etc.), which are responsible for providing nutrients and support to neurons. White matter is tissue made mostly of neuronal axons that are insulated by a lipid sheath known as myelin. Myelin allows for saltatory conduction, enabling the brain to send action potentials at higher speeds. Thus, gray- and white-matter regions complement each other and work together to relay impulses efficiently and quickly.

Brain lesion studies suggest that the PFC plays an important role in executive functioning (Bissonette, Powell, & Roesch, 2013), but the specific regions within the PFC that are relevant have yet to be fully identified. This project used quantitative magnetic resonance imaging (qMRI) to obtain grey-white matter contrast (GWC) as a measurement of prefrontal lobe brain structure integrity. The less contrast there is, the more blurring occurs at the junction between the cortical gray matter and adjacent white matter. Blurring can occur when neurons designated for gray matter get stuck in the white matter during cortical development. GWC is measured by computing a ratio of signal intensity values in the gray matter above the gray-white junction to signal intensity values in the white matter below. It was chosen as a measure of cortical structural integrity due to previous findings that it is linearly related to decreased language function bilaterally in the temporal, parietal and frontal regions and that it is a mediator of group differences in cognitive performance between patients with epilepsy and healthy controls (Blackmon et al., 2014). While the ratio of grey matter to white matter volume has proven to be a useful brain image modality, previous studies mostly used this for the investigations involving brain aging and Alzheimer’s disease (Taki, Thyreau, Kinomura, Sato, & Goto, 2011).

This study analyzes cognitive performance based on cognitive set shifting, which involves alternating between one task and another. An example is switching back and forth from solving a
math problem to answering an email. Shifting from one activity to another can be difficult for some people, especially if the tasks require close attention. Difficulty in shifting between tasks is known as cognitive rigidity, which can be an indication of many different human psychiatric disorders and a lack of sufficient executive function (Chan, Shum, Toulopoulou, & Chen, 2008). Difficulty in set-shifting is often noticed in conditions such as autism spectrum disorder, Alzheimer’s dementia, major depression disorder and other neuropsychiatric conditions (Elliott, 2003). On the other hand, cognitive flexibility enables individuals to focus their attention on a number of different tasks.

Neuropsychological tests have been shown to be useful in assessing higher order functioning (Lezak, Howieson, Bilger, & Tranel, 2012). In this study, two neuropsychological tests were used to assess set-shifting abilities: Trail Making Test-B (TMT-B) (created by the Army for the Individual Tests of General Ability) and the Wisconsin Card Sorting Test Perseverative Errors (WCST-PE).

The TMT-B requires participants to connect dots that are labeled either numerically or alphabetically in an ascending alphabetic sequence. The TMT-B requires participants to hold in mind three different criteria: shape, number and color, as they try to find the rule set by the test proctor. In both TMT-B and WCST-PE, having to switch between more than one category of thought requires participants to tap into their executive functioning skills. Struggling with these set-shifting tasks may signify problems with participants’ PFC and executive functioning abilities (Bissonnette et al., 2013).

Previous studies have demonstrated a correlation between GWC in the PFC and decreased cognitive functioning, but the specific subregions within the PFC are yet to be fully elucidated. This investigation used both qMRI and neuropsychological measures to investigate which PFC subregions have the strongest relationships with cognitive set shifting. Specifically, this study explored the correlation between healthy participants’ TMT-B and WCST-PE scores and average GWC in eight regions of interest (ROI): the left (Broca’s area) and right ventrolateral PFC, the left and right middle frontal gyri (dorsolateral PFC), the left and right superior frontal lobes, and the left and right orbitofrontal cortices (OFC).

The OFC was used as a negative control as it is known to function in reward and emotion processing, but not in set shifting (Kringelbach, 2004).

The following hypotheses were tested in this investigation: 1) there will be a positive correlation of GWC of the left- and right-hemisphere superior frontal gyri with TMT-B and WCST-PE scores (higher scores indicate worse cognitive set-shifting abilities); 2) there will be no correlation of GWC in the left or right orbitofrontal cortex (OFC) with TMT-B and WCST-PE scores; 3) there will be a positive correlation of GWC of the left ventrolateral PFC with TMT-B and WCST-PE scores; 4) there will be a positive correlation of GWC in the left and right middle frontal gyri (dorsolateral PFC) with TMT-B and WCST-PE scores; and 5) there will be no correlations of GWC in any of the prefrontal lobe brain regions with performance on the BNT. This study will potentially pinpoint the exact area of the brain that malfunctions in people who struggle with set-shifting, for example, those who are affected with autism, Down’s syndrome and attention deficit hyperactivity disorder (ADHD).

MATERIALS AND METHODS

Ethics Statement

The study had current approval by the Institutional Review Board (IRB) at New York University and was conducted in accordance to the Declaration of Helsinki (1964, 2008). All subjects participated voluntarily were given detailed information about the study and gave written consent before participating in the study.

Participants

61 healthy adults (31 males/30 females) with no history of neurological disease, psychiatric illness, developmental learning disorders or traumatic brain injury volunteered to take a series of tests to measure their cognitive set-shifting abilities and to undergo MRI scanning at the New York University Center for Brain Imaging. Their ages ranged from 15 to 70 years at the time of scanning. M

Figure 1. Computing GWB: Sampling points on T1-weighted MPRAGE image with gray-white (GW) junction surface (yellow line) and pial surface (red line). The blue dot represents the sampling location of the gray matter intensity value at 0.5 mm into the gray matter relative to the GW junction. The purple dot shows the sampling location of the white matter intensity value at 0.5 mm into the white matter relative to the GW junction (adapted from Blackmon et al., 2014).
= 31.94 years, SD = 13.34). Group education levels were similar across subjects (M = 15.96 years, SD = 1.91). There were 56 right-handed participants, 4 left-handed participants and 1 ambidextrous participant.

MRI Scanning

Imaging was performed at the NYU Center for Brain Imaging on a 3T head-only MRI scanner (Siemens, New York). Image acquisition included a conventional three-plane localizer and two T1-weighted gradient-echo sequence (MPRAGE) volumes (TE = 3.25 ms, TR = 2530 ms, TI = 1.100 ms, flip angle = 7°, FOV = 256 mm, voxel size = 1×1×1.33 mm). Acquisition parameters were optimized for increased gray-white matter image contrast.

Gray-White Matter Contrast (GWC)

GWC values were obtained by sampling T1 image intensity contrast at both 0.5 mm above and below the gray-white interface with trilinear interpolation. These values were used to create a ratio score: (gray - white)/(gray + white) (Figure 1). Four main processes were involved: (1) segmentation of the white matter; (2) patchwork of the gray-white matter surfaces; (3) inflation of the folded surface; and (4) automatic correction of topological defects (Dale, Fischl, & Sereno, 1999). GWC values ranged from -1 to 0, where scores closer to zero represent higher degrees of blurring around the gray-white inner surface. Mean GWC values were extracted for each participant for each of the following ROIs: the left (Broca's) and right ventrolateral PFC, the left and right middle frontal gyri (dorsolateral PFC), the left and right superior frontal gyri, and the left and right orbitofrontal cortices (OFC). Images were further processed with the FreeSurfer (4.0.2) software package (http://surfer.nmr.mgh.harvard.edu). Mean signed curvature was estimated at each vertex using standard FreeSurfer, giving a measure of the “sharpness” of cortical folding, differentiating between gyral and sulcal regions.

Cognitive Assessments

1. Trail Making Test B (TMT-B)

TMT-B was designed to test an individual’s set-shifting ability through a task that involves connecting dots in an alphanumeric manner (Figure 2). As this test involves continually switching between the letters and numbers very quickly, it has been shown to be effective in determining cognitive set-shifting ability. The participant is given a sheet of paper with both numerically and alphabetically labeled dots, and the goal is to connect them as quickly as possible in ascending order (1-A-2-B-3-C…, etc.). Scoring is based on the time it takes for the participant to complete the test. Longer times of test completion are represented by higher scores, indicating lower performance in the test and, thus, poorer set-shifting ability (Spreen & Strauss, 1991).

2. Wisconsin Card Sorting Test-Perseverative Errors (WCST-PE)

The WCST-PE was designed to test cognitive set-shifting abili-
ties by having the participant match cards according to concealed rules set by a test conductor (Figure 3). The test conductor places four cards in a line in front of the participant and then sets a concealed organizational rule based on color, pattern, number or type of shape. The participant is given several stimulus cards with images of various shapes, colors and numbers, and has to place each in one of the four piles set by the test conductor. Through trial and error, the participant attempts to place the cards into the piles according to the hidden rule. The test conductor only tells the participant whether the match is correct or incorrect. Once the participant correctly identifies the rule, the test proctor changes it without telling the participant. For instance, the rule can change from matching color to matching shape. Scoring is based on the participant’s number of perseverative errors: the number of times the participant puts down a card not in line with the conductor’s current rule, but consistent with a previously successful rule. In other words, these errors reflect difficulty in switching from a previously successful rule to a new rule. Higher numbers of perseverative errors on this task indicate higher total scores and poorer test performance (Spreen et al., 2006).

3. Boston Naming Test (BNT)
The BNT was the only non-set-shifting test administered and was used to measure a type of language ability known as word retrieval. The test consists of 60 pictures of various objects shown to the participant in order of increasing difficulty (high- to low-frequency objects) (Figure 4). Each participant is given a time limit of 20 s to correctly name all 60 images. If the participant fails to give the correct response, the examiner may give the participant the initial sound of the target word. The examiner scores each item + or – according to the scoring procedures (max score = 60). Higher scores indicate better performance in this test (Spreen et al., 1991). The Boston Naming Test (BNT) was used as a measure of discriminant validity to determine whether PFC findings are specific to cognitive set-shifting abilities and not cognitive functioning in general. The BNT is considered a measure of language ability that does not rely on PFC to the same extent as executive functioning measures (Lezak et al., 2012). Thus, the BNT was used as a negative control to ensure that GWC in PFC subregions were correlated only with set-shifting abilities.

**Statistical Analyses**

GWC averages from each participant were calculated for the eight PFC regions of interest. TMT-B, WCST-PE and BNT test scores were available for each participant. Two-tailed Pearson correlation r-tests were run between mean GWC values in each ROI and scores from each neuropsychological test. Results were evaluated for statistical significance using a threshold of \( p < 0.05 \). This threshold was adjusted to account for multiple comparisons using the Bonferroni correction, requiring division of the p-value threshold by the number of tests administered for each dependent variable. Given that eight different ROIs were tested for each dependent variable, the p-value of 0.05 was divided by eight to determine a Bonferroni threshold of \( p < 0.00625 \).

**RESULTS**

Five regions were found to have GWC values significantly correlated with at least one set-shifting test (Figures 5-7). All significant correlations were positive and linear; increased GWC was associated with increased set-shifting scores, indicating worse performance. Out of the eight PFC subregions, four regions had GWC values that were significantly correlated with WCST-PE scores (\( M = 8.4 \) perseverative errors, \( SD = 6.3 \)): the left superior frontal gyrus, right superior frontal gyrus, left middle frontal gyrus (dorsolateral PFC) and left ventrolateral PFC (Broca’s). In addition, four regions had GWCs that were significantly correlated with TMT-B scores (\( M = 71.1 \) seconds, \( SD = 41.2 \)): the left ventrolateral PFC (Broca’s), right middle frontal gyrus (dorsolateral PFC), left superior frontal gyrus and the right superior frontal gyrus. No correlations were found between the Boston Naming Test scores (BNT) (\( M = 53.2 \) correct identifications, \( SD = 5.0 \)) and any of the eight PFC subregions (\( M \) GWC of all eight ROIs = -0.13, \( SD = 0.011 \)). Table 4 shows the mean GWC of all eight ROIs and the standard deviation.

**GWC and Trail Making Test B (TMT-B)**

Correlations between GWC values from the eight PFC subregions and each participant’s TMT-B score were analyzed. GWC values in four regions were found to have significant correlations with TMT-B performance after adjustment for multiple comparisons: the left ventrolateral PFC (Broca’s area) (\( r = 0.36, p = 0.005 \)), the right middle frontal gyrus (dorsolateral PFC) (\( r = 0.39, p = 0.002 \)), the left superior frontal gyrus (\( r = 0.40, p = 0.002 \)) and the right superior frontal gyrus (\( r = 0.42, p = 0.001 \)). GWC values from the four remaining ROIs did not have significant correlations with TMT-B performance after adjustment for multiple comparisons: the right ventrolateral PFC (\( r = 0.33, p = 0.009 \)), left middle frontal gyrus (\( r = 0.34, p = 0.007 \)), left orbitofrontal cortex (\( r = 0.13, p = 0.341 \)) and right orbitofrontal cortex (\( r = 0.17, p = 0.190 \)) (Figure 5).
Figure 5. The scatter plots show the relationship between the time for the participants to complete TMT-B. (A) left superior frontal gyrus, (B) right superior frontal gyrus, (B) left ventrolateral gyrus, and (D) right middle frontal gyrus GWB. Longer time for TMT-B completion reflects poorer performance and greater values for GWB.

Figure 6. The scatter plots show the relationship between the time for the participants to complete WCST-PE. (A) left superior frontal gyrus, (B) right superior frontal gyrus, (C) left ventrolateral gyrus, and (D) left middle frontal gyrus GWB. Greater number of errors on WCST-PE reflects poorer performance and greater values for GWB.
Correlations between PFC GWC and set-shifting abilities were analyzed in 61 healthy participants. This study tested for five factors: 1) a positive correlation of GWC in the left and right hemisphere superior frontal gyri with TMT-B and WCST-PE test scores; 2) no correlation of GWC in the left or right OFC with TMT-B and WCST-PE test scores; 3) a positive correlation of GWC in the left ventrolateral PFC with TMT-B and WCST-PE test scores; 4) a positive correlation of GWC in the left and right middle frontal gyri (dorsolateral PFC) with performance TMT-B and WCST-PE and 5) a positive correlation of GWC in the left and right middle frontal gyri with TMT-B and WCST-PE test scores; values with asterisks are significant after Bonferroni correction for multiple comparisons.

**DISCUSSION**

Correlations between PFC GWC and set-shifting abilities were analyzed in 61 healthy participants. This study tested for five factors: 1) a positive correlation of GWC in the left and right hemisphere superior frontal gyri with TMT-B and WCST-PE test scores; 2) no correlation of GWC in the left or right OFC with TMT-B and WCST-PE test scores; 3) a positive correlation of GWC in the left ventrolateral PFC with TMT-B and WCST-PE test scores; 4) a positive correlation of GWC in the left and right middle frontal gyri (dorsolateral PFC) with performance TMT-B and WCST-PE performance after adjustment for multiple comparisons: the left ventrolateral gyrus (Broca’s area) \( (r = 0.38, p = 0.003) \), the left middle frontal gyrus \( (r = 0.35, p = 0.006) \), the left superior frontal gyrus \( (r = 0.37, p = 0.004) \) and the right superior frontal gyrus \( (r = 0.36, p = 0.004) \). GWC values from the four remaining ROIs did not have significant correlations with WCST-PE performance after adjustment for multiple comparisons: right ventrolateral PFC \( (r = 0.27, p = 0.039) \), right middle frontal gyrus \( (r = 0.33, p = 0.009) \), left orbitofrontal cortex \( (r = 0.27, p = 0.038) \) and right orbitofrontal cortex \( (r = 0.24, p = 0.067) \). Figure 6).

**GWC and Boston Naming Test (BNT)**

There were no significant correlations between GWC values from the eight ROIs and BNT performance: the left ventrolateral gyrus (Broca’s area) \( (p = .547) \), left middle frontal gyrus \( (p = 0.570) \), left superior frontal gyrus \( (p = 0.570) \), left orbitofrontal cortex \( (p = 0.355) \), right ventrolateral gyrus \( (p = 0.618) \), right middle frontal gyrus \( (p = 0.501) \), right superior frontal gyrus \( (p = 0.754) \), left orbitofrontal cortex \( (p = 0.355) \), and right orbitofrontal cortex \( (p = 0.836) \). Table 3).

**TMT-B & WCST-PE and BNT**

It was found that TMT-B performance was significantly correlated with WCST-PE performance \( (r = 0.392, p = 0.002) \) (Figure 7). Both TMT-B performance \( (p = 0.088) \) and WCST-PE performance \( (p = 0.266) \) were not significantly correlated with BNT.

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**Table 1. Correlation coefficients \( r \) and \( p \)-values for correlations between GWC of all brain regions tested with TMT-B and WCST-PE neuropsychological test performance.** Values with asterisks are significant after Bonferroni correction for multiple comparisons.

<table>
<thead>
<tr>
<th>PFC Region GWC</th>
<th>TMT-B</th>
<th>WCST-PE</th>
<th>BNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Ventrolateral Gyrus</td>
<td>( r = 0.36 )</td>
<td>( r = 0.38 )</td>
<td>( r = 0.079 )</td>
</tr>
<tr>
<td>( p = 0.005^* ) &amp; ( p = 0.003^* ) &amp; ( p = 0.547 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Middle Frontal Gyrus</td>
<td>( r = 0.34 )</td>
<td>( r = 0.35 )</td>
<td>( r = 0.075 )</td>
</tr>
<tr>
<td>( p = 0.007 ) &amp; ( p = 0.066 ) &amp; ( p = 0.570 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Superior Frontal Gyrus</td>
<td>( r = 0.40 )</td>
<td>( r = 0.37 )</td>
<td>( r = 0.066 )</td>
</tr>
<tr>
<td>( p = 0.002^* ) &amp; ( p = 0.064 ) &amp; ( p = 0.618 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Orbitofrontal Cortex</td>
<td>( r = 0.13 )</td>
<td>( r = 0.27 )</td>
<td>( r = 0.121 )</td>
</tr>
<tr>
<td>( p = 0.341 ) &amp; ( p = 0.355 ) &amp; ( p = 0.501 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Ventrolateral Gyrus</td>
<td>( r = 0.33 )</td>
<td>( r = 0.27 )</td>
<td>( r = 0.089 )</td>
</tr>
<tr>
<td>( p = 0.009 ) &amp; ( p = 0.039 ) &amp; ( p = 0.501 )</td>
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<td></td>
</tr>
<tr>
<td>Right Middle Frontal Gyrus</td>
<td>( r = 0.39 )</td>
<td>( r = 0.33 )</td>
<td>( r = 0.041 )</td>
</tr>
<tr>
<td>( p = 0.002^* ) &amp; ( p = 0.099 ) &amp; ( p = 0.754 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Superior Frontal Gyrus</td>
<td>( r = 0.42 )</td>
<td>( r = 0.36 )</td>
<td>( r = 0.064 )</td>
</tr>
<tr>
<td>( p = 0.001^* ) &amp; ( p = 0.04^* ) &amp; ( p = 0.625 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Orbitofrontal Gyrus</td>
<td>( r = 0.17 )</td>
<td>( r = 0.24 )</td>
<td>( r = 0.027 )</td>
</tr>
<tr>
<td>( p = 0.190 ) &amp; ( p = 0.067 ) &amp; ( p = 0.836 )</td>
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</tbody>
</table>

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**Table 2. Mean and standard deviation of demographics: age at time of scan, age at time of neuropsychology examination, and years of education of all the subjects.**

<table>
<thead>
<tr>
<th>Age at Time of Scan</th>
<th>Age at Time of Neupropsych</th>
<th>Years of Education</th>
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<tbody>
<tr>
<td>Mean</td>
<td>31.9</td>
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<tr>
<td>Standard Deviation</td>
<td>13.3</td>
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</tr>
<tr>
<td></td>
<td>15.9</td>
<td>1.9</td>
</tr>
</tbody>
</table>

**Table 3. Correlations between the three neuropsychology tests; values with asterisks are significant after Bonferroni correction for multiple comparisons.**

<table>
<thead>
<tr>
<th>WCST-PE</th>
<th>BNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMT-B</td>
<td>( r = 0.39 )</td>
</tr>
<tr>
<td>( p = 0.002^* ) &amp; ( p = 0.088 )</td>
<td></td>
</tr>
<tr>
<td>BNT</td>
<td>( r = 0.15 )</td>
</tr>
<tr>
<td>( p = 0.266 ) &amp; ----</td>
<td></td>
</tr>
</tbody>
</table>

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**GWC and Wisconsin Card Sorting Test-Preservative Errors (WCST-PE)**

Correlations between GWC values from the eight PFC subregions and each participant’s WCST-PE score were analyzed. GWC values in four regions were found to have significant correlations with WCST-PE performance after adjustment for multiple comparisons: the left ventrolateral gyrus (Broca’s area) \( (r = 0.38, p = 0.003) \), the left middle frontal gyrus \( (r = 0.35, p = 0.006) \), the left superior frontal gyrus \( (r = 0.37, p = 0.004) \) and the right superior frontal gyrus \( (r = 0.36, p = 0.004) \). GWC values from the four remaining ROIs did not have significant correlations with WCST-PE performance after adjustment for multiple comparisons: right ventrolateral PFC \( (r = 0.27, p = 0.039) \), right middle frontal gyrus \( (r = 0.33, p = 0.009) \), left orbitofrontal cortex \( (r = 0.27, p = 0.038) \) and right orbitofrontal cortex \( (r = 0.24, p = 0.067) \). Figure 6).

**GWC and Boston Naming Test (BNT)**

There were no significant correlations between GWC values from the eight ROIs and BNT performance: the left ventrolateral gyrus (Broca’s area) \( (p = .547) \), left middle frontal gyrus \( (p = 0.570) \), left superior frontal gyrus \( (p = 0.570) \), left orbitofrontal cortex \( (p = 0.355) \), right ventrolateral gyrus \( (p = 0.618) \), right superior frontal gyrus \( (p = 0.625) \), right ventrolateral gyrus \( (p = 0.501) \), right middle frontal gyrus \( (p = 0.754) \), left orbitofrontal cortex \( (p = 0.355) \), and right orbitofrontal cortex \( (p = 0.836) \). (Table 3).
test scores; and 5) no correlations of GWC in any PFC region with performance on the BNT. The results are consistent with these hypotheses. One slight incongruence between our hypotheses and results is that the left and right middle frontal gyrus (dorsolateral PFC) were split in their correlations with set-shifting performance. GWC in the left middle frontal gyrus was correlated with only WCST-PE scores, whereas GWC from the right middle frontal gyrus was correlated with only TMT-B scores. These findings suggest that set shifting is not controlled by the entire PFC, but by certain PFC subregions instead, and that different types of set shifting are correlated with different patterns of PFC subregion involvement.

Few existing studies map PFC subregions to specific functions. One domain of cognition that is thought to be localized to the PFC is a set of processes known as executive functions. This study focused on a type of executive function known as set shifting, or the ability to alternate between two or more tasks. There are multiple types of set shifting that vary based on the additional component of processes involved (i.e., visual or motor). Some studies have localized set-shifting ability to the frontal parietal area; however, findings have been inconsistent due to methodological differences across studies (Pa et al., 2010). The effects of these differences are particularly amplified in studies of higher-order cognition due to the vast and relatively unknown networks involved. In order to maintain a narrower focus, this study concentrated on a few subregions within the PFC and just two types of set shifting. Although this decreased the scope of the study, it allowed for a more thorough analysis of a brain region previously implicated in set-shifting abilities, and the Desikan parcellation method allowed for increased localization specificity. Previous functional neuroimaging studies have found that lateral frontal lobe areas are most vital to set shifting (Pa et al., 2010). This study analyzed six lateral frontal lobe areas and two orbital frontal lobe areas. Orbital regions of the frontal lobe have not been found to correlate with set-shifting ability and thus served as negative controls in the set shifting correlation analyses (Bissonette et al., 2013).

GWC was used to measure the structural integrity of the PFC regions, as it is a marker of cortical development and myelin density. Interruptions during normal brain development can cause neurons to get stuck in the white matter during neuronal migration, resulting in increased GWC. Blurring of gray and white matter in certain brain regions has been correlated with decreased performance on neuropsychological tests of cognitive performance, such as the Wechsler Adult Intelligence Scale (WAIS), Boston Naming Test (BNT) and Controlled Oral Word Association (FAS and CFL) (Blackmon et al., 2011). Moreover, correlations between PFC structures and set shifting have been found in certain animals such as monkeys, rats, and mice (Bissonette et al., 2013). Expanding upon these works, this study demonstrates how set shifting is associated with GWC in different PFC regions in healthy adults.

Both the set-shifting neuropsychological tests used, TMT-B and WCST-PE, require attention, working memory, visual search and executive-functioning abilities to varying extents (Fujiki et al., 2013). Higher TMT-B scores reflect difficulty in switching men-
frontal cortex to set shifting, and as expected there were no correlations between the left or right OFC with either test.

**PFC GWC Associations with the BNT**

The Boston Naming Test was used to establish discriminant validity by demonstrating that GWC in prefrontal regions is correlated with cognitive set shifting specifically and not cognitive functioning in general. The fact that the two cognitive set shifting measures were not correlated with the BNT provides support that the BNT is an independent measure of cognitive function unrelated to cognitive set shifting. Prior studies have demonstrated that intact performance on the BNT requires temporal lobe integrity, rather than frontal lobe (Loring et al., 2008). Results from current study confirmed this as no PFC regions correlate with the BNT. It is unclear whether GWC in temporal lobe regions is correlated with BNT scores; however, this would be a valuable hypothesis to test in future studies. Most regions tested in this study have no correlation with speech production or speech comprehension except for the left superior frontal gyrus, and, as expected, GWC in these areas did not correlate with the BNT. Even the left superior frontal gyrus did not correlate with the BNT, which supports the theories that slow deterioration of Broca’s area can trigger compensatory mechanisms from surrounding areas (Plaza, Gatignol, Leroy, & Duffau, 2009). Since GWC is not an abrupt occurrence, neural plasticity is able to compensate for the deterioration of function.

**Neuropsychology Test Associations (TMT-B, WCST-PE, BNT)**

Since both TMT-B and WCST-PE test for set shifting, their correlation was highly significant as expected. However, the difference between the tests could be observed in the mid frontal gyrus. The two tests assessed different cognitive functions in addition to set-shifting ability. Using cards with pictures of various colors and shapes, WCST-PE tested response inhibition and novel problem solving as the participant had to inhibit a prior response pattern that was no longer successful and use trial and error to solve for the hidden rule. TMT-B, on the other hand, evaluated sequencing and visual attention when the participant had to connect dots in alphanumerical order. Both TMT-B and WCST-PE did not correlate significantly with BNT since BNT measures confrontational word retrieval whereas both TMT-B and WCST-PE focus mainly on executive functioning.

Although this study was conducted methodically with the use of the same scanner, processing steps and neuropsychological tests in each participant, the research could have been improved in several ways. One way would be to consider measures of frontal white matter integrity such as those acquired from diffusion tensor imaging. Numerous studies have shown the impact of white matter hyperintensities and compromised fiber tracts on impaired set-shifting performance among other executive functioning abilities (Perry et al., 2009). This study was conducted in 61 participants, a population which could have possibly restricted the generalizability of the findings to patient populations and limited the amount of variance in the data, so further studies may benefit from a larger sample size. Also, there was a wide range of ages among the participants, which should be restricted in future studies.

The next steps would be to develop treatment options for people with executive dysfunctions. Currently, there are no specific medications that help people struggling with these problems. As cognitive set-shifting deficits may be related to certain behaviors of those diagnosed with autism spectrum and individuals diagnosed with ADHD, this research could be essential in developing treatments for these conditions. Future directions for similar research need to focus on whether white-matter integrity in the PFC subregions show a similar pattern of results in repeated trials. Moreover, this study tested not only set-shifting ability, but also other skills sets such as sequencing and working memory. Controlling for component processes to isolate set-shifting ability could have led to confounding interactions between component processes (Pa et al., 2010). In addition, instead of using a test to assess set-shifting ability along with component processes simultaneously, an alternative test, the Design Fluency (DF) test, could be used to assess solely set-shifting abilities. In the Design Fluency test, participants first connect filled dots while avoiding the empty dots and then connect the empty dots while avoiding the filled dots. The test breaks down into three different criteria: elimination of extraneous component processes, generation of original ideas and provision for the allowance of the participant to focus on set shifting. Future tests should determine whether this test is correlated with TMTB and WCST-PE and show a similar pattern of correlations with GWC in PFC subregions.

**CONCLUSION**

In sum, this study demonstrates a positive correlation between cognitive set-shifting ability and GWC in specific parts of the PFC. This investigation tested eight different PFC regions that previous studies have marked as controls of the set-shifting abilities, or that can be useful in verifying some hypotheses which were made prior to this study. Our experimental method--using WCST-PE, TMT-B and BNT--showed that GWC in circumscribed regions of the PFC correlated with WCST-PE and TMT-B. WCST-PE correlated with GWC values in the left ventrolateral gyrus (Broca’s), the left and right superior frontal gyrus, and the left mid frontal gyrus. TMT-B correlated with the left ventrolateral gyrus (Broca’s), the left and right superior frontal gyrus, and the right mid frontal gyrus. The right ventrolateral gyrus (Broca’s) and the left and right OFC were not correlated with any of the tests. This study will provide opportunities for future research to target the specific areas of the prefrontal cortex that are inhibited in people who struggle with set shifting. As a result of these findings, potential treatments can be designed to aid individuals with disorders such as autism, Down’s syndrome and ADHD that impair set-shifting abilities.

**REFERENCES**


Blackmon, K., Kuzniecky, R., Barr, W. B., Snuderl, M., Doyle, W., Devinsky, O.,
Comparison of Dark Matter Proportions Across Types of Spiral Galaxies

M. Elliott Williams¹, Amy Lovell²

A large obstacle on the path to better understanding the evolution of the Universe is knowing the extent to which “nature” and “nurture” affect structures in our Universe. Recent studies have observed that many galactic properties such as luminosity and morphology are dependent on their environment and in particular, their halos, from the galactic cluster scale down to galaxy groups. In this study, we investigate the relationship between dark matter (as a fraction of the total mass of the galaxy) and morphology of individual galaxies to determine if a similar relationship between galaxies and their environment exists at this scale. Our approach differs in the sense that we look at the proportion rather than the actual value of the characteristic we are studying to control for the size of the galaxies. We select the sample from Sa, Sb, and Sc type galaxies, where the spiral arms of Sa galaxies are the tightest and those of Sb, Sc are increasingly more unwound. While unable to statistically prove due to the sample size, an increasing trend in the dark matter fractions was observed between Sa and Sb type galaxies apart from NGC 4594. Little to no trend was discernable in dark matter between Sb and Sc type galaxies. We suggest a larger sample size and controlling for the environment in future experiments.

INTRODUCTION

The current cosmological model of the early formation of stars and galaxies in the Universe involves dark matter, a type of theorized matter that interacts only through the gravitational force and possibly the weak force, that grouped together to form halos that provided a framework for the structure of the Universe. Clouds of baryonic gas converged in these dark matter halos in the early Universe. As more gas was accumulated through mergers and fell into the halos, the gas formed rapidly spinning disks that were the first protogalaxies. Astrophysicists today continue to study dark matter halos and their evolution to better understand their role in forming the different types of galaxies we observe.

Galaxies are sorted by their structure into morphological classes using criteria established by Edwin Hubble and others (Hubble, 1926; van den Bergh, 1960a, 1960b). Studying the shape and structure of galaxies can provide valuable information about their birth and evolution. As advancements have been made over the past de-cades in the observation techniques and instruments used to study galaxies, astrophysicists have been able to study galaxies in more depth across the electromagnetic spectrum. Identifying galactic structure from multiple wavelengths has brought about a broader and more detailed classification of galaxies in the Universe.

The bottom-up theory of structure formation in the Universe argues that galaxy groups and clusters formed from smaller structures and grew through mergers and other interactions between structures (White, & Rees, 1978). In the past 40 years, it has become more apparent that galactic properties such as morphology and luminosity are linked to their environments (Postman, & Geller, 1983; Zabludoff, & Mulchaey, 1998). Weinmann, van den Bosch, Yang, and Mo (2006) found relationships between galaxy properties and halo mass scale smoothly from clusters to groups, providing evidence towards the bottom-up scenario and precedence for studying the relationship between dark matter and galaxy characteristics.

In this study, we investigate the dark matter in a sample of regular spiral galaxies. We are looking to find a trend between dark matter content and morphological type. This could suggest that the influence dark matter has on the structure of the Universe begins on as small a scale as individual galaxies. To test this, we will take light data for seven different galaxies in visible wavelengths. Combined with published rotation curves data and published gas mass data, we will compute dark matter fractions for three Sa, two Sb, and two Sc type galaxies and discuss any trends observed.

MATERIALS AND METHODS

The aim of this experiment is to test for a trend between morphological type and dark matter content. There are many processes the light data and rotational velocity data go through to produce dark matter fractions, so it is important to be cognizant of the uncertainty present in the calculations. To minimize uncertainties, we control as many factors as possible. Controlled factors are as follows:

- Johnson-Cousins Filter Images:
**Absolute Magnitude of -18 to -22**

**Gravitational Constant:**

- Mass of $10^9$ to $10^{12}$ Solar masses

**Kroupa Initial Mass Function:**

- Solar Mass:

**SA Spiral Galaxies:**


**Galaxy Sample**

We selected the galaxies with the aim to avoid introducing un-wanted variables into the data. The profile of a “normal” spiral galaxy was adopted by looking at galaxies from Zombeck (1990, pp. 83-85). All galaxies chosen fell into the similar ranges that Zombeck observed (Table 1, Table 2):

- Mass of $10^9$ to $10^{12}$ Solar masses
- Absolute Magnitude of -18 to -22
- Diameter of ~5 to 40 kpc

**NGC 4565** has a diameter outside the range seen in Zombeck (1990) but was still included because it has been in previous studies involving dark matter (Table 1).

**Seyfert AGN**

Three of the galaxies included in the study are Seyfert galaxies (NGC 4378, NGC 4565, and NGC 7314). Seyferts have been observed to fluctuate in luminosity over periods as long as years and as short as days because of their active nuclei (that are very luminous). This may affect the stellar mass calculations because these fluctuations come from non-stellar sources.

**Observations**

A summary of the observations is visible in Table 3. The 1 m SARA-North Telescope operates at the Kitt Peak National Observatory in Arizona, USA, and the 0.6 m SARA-South Telescope operates at the Cerro Tololo Inter-American Observatory in Chile. The galaxies studied were NGC 4378, NGC 4594, NGC 6314, NGC 2841, NGC 4565, NGC 4682, and NGC 7314 (Figure 1, Figure 2, Figure 3).

**Techniques**

We take all filtered photometric data in Johnson-Cousins B, V, and R filters (Cousins, 1974a, 1974b; Johnson, 1953).

**SA Spiral Galaxies:**

All galaxies in the sample are unbarred spiral galaxies to eliminate uncertainty in the event that bar structures affect the dark matter fraction (or vice versa).

**Hubble Constant:**

We adopt a value of $H_0 = 74.4$ (kms$^{-1}$)Mpc$^{-1}$ for distances and radii (de Vaucouleurs et al., 1991). We adjust all distance and radii measurements using this number to produce precise and homogenized results.

**Kroupa Initial Mass Function:**

We calculate mass to light ratios assuming the Kroupa Initial Mass Function (IMF). This is chosen for its modernity and its low uncertainty in higher solar mass values (Kroupa, 2001).

**Absolute Magnitude of Sun:**

We adopt the value 4.83 for the absolute magnitude of the Sun (Williams) for magnitude and luminosity calculations.

**Solar Mass:**

We use the value $1.9885 \times 10^{30}$ kg for one solar mass (Williams). This parameter is used for luminosity calculations.

**Gravitational Constant:**

We use a recently published value, $6.67408 \times 10^{-11}$ m$^3$kg$^{-1}$s$^{-2}$, for the Gravitational constant in dynamical mass calculations (Mohr, Newell, & Taylor, 2015).

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Table 1. Properties of Observed Galaxies.

<table>
<thead>
<tr>
<th>Galaxy (1)</th>
<th>Type (2)</th>
<th>D (Mpc) (3)</th>
<th>$m_r$ (mag) (4)</th>
<th>$M_*$ (mag) (5)</th>
<th>$L_\odot$ (10$^{10}$ L$\odot$) (6)</th>
<th>$M^* (10^9 M_\odot)$ (7)</th>
<th>Ref. (8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGC 4378*</td>
<td>Sa</td>
<td>35.54</td>
<td>11.33</td>
<td>-21.42</td>
<td>3.17</td>
<td>8.40</td>
<td>1, 3</td>
</tr>
<tr>
<td>NGC 4594</td>
<td>Sa</td>
<td>11.27</td>
<td>9.28</td>
<td>-20.98</td>
<td>2.11</td>
<td>4.39</td>
<td>2, 3</td>
</tr>
<tr>
<td>NGC 6314</td>
<td>Sa</td>
<td>80.9</td>
<td>13.22</td>
<td>-21.32</td>
<td>2.88</td>
<td>3.39</td>
<td>2, 3</td>
</tr>
<tr>
<td>NGC 2841</td>
<td>Sb</td>
<td>14.59</td>
<td>9.69</td>
<td>-21.13</td>
<td>2.42</td>
<td>3.73</td>
<td>2, 3</td>
</tr>
<tr>
<td>NGC 4565**</td>
<td>Sb</td>
<td>13.5</td>
<td>9.73</td>
<td>-20.92</td>
<td>2.00</td>
<td>1.59</td>
<td>2, 3</td>
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<td>NGC 4682</td>
<td>Sc</td>
<td>29.9</td>
<td>13.08</td>
<td>-19.30</td>
<td>0.45</td>
<td>0.38</td>
<td>3</td>
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<tr>
<td>NGC 7314*</td>
<td>Sc</td>
<td>17.38</td>
<td>11.91</td>
<td>-19.29</td>
<td>0.44</td>
<td>0.31</td>
<td>2, 3</td>
</tr>
</tbody>
</table>

Table 2. Derived Stellar Mass values of Observed Galaxies.

<table>
<thead>
<tr>
<th>Galaxy (1)</th>
<th>Type (2)</th>
<th>$D$ (Mpc) (3)</th>
<th>$m_r$ (mag) (4)</th>
<th>$M_*$ (mag) (5)</th>
<th>$L_\odot$ (10$^{10}$ L$\odot$) (6)</th>
<th>$M^* (10^9 M_\odot)$ (7)</th>
<th>Ref. (8)</th>
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<td>-21.42</td>
<td>3.17</td>
<td>8.40</td>
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</tr>
<tr>
<td>NGC 4594</td>
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<td>-20.98</td>
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<tr>
<td>NGC 6314</td>
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<td>80.9</td>
<td>13.22</td>
<td>-21.32</td>
<td>2.88</td>
<td>3.39</td>
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</tr>
<tr>
<td>NGC 2841</td>
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<td>14.59</td>
<td>9.69</td>
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<td>2.42</td>
<td>3.73</td>
<td>2, 3</td>
</tr>
<tr>
<td>NGC 4565**</td>
<td>Sb</td>
<td>13.5</td>
<td>9.73</td>
<td>-20.92</td>
<td>2.00</td>
<td>1.59</td>
<td>2, 3</td>
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<tr>
<td>NGC 4682</td>
<td>Sc</td>
<td>29.9</td>
<td>13.08</td>
<td>-19.30</td>
<td>0.45</td>
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<td>3</td>
</tr>
<tr>
<td>NGC 7314*</td>
<td>Sc</td>
<td>17.38</td>
<td>11.91</td>
<td>-19.29</td>
<td>0.44</td>
<td>0.31</td>
<td>2, 3</td>
</tr>
</tbody>
</table>
Radii to the 25 mag arcsec$^{-2}$ surface brightness level measured in the B band were calculated manually from published values of the distance to the galaxies and their apparent size (that use the same blue 25 mag arcsec$^{-2}$ criterion). The formula,

$$r = D \frac{\pi \theta}{648},$$  \hspace{1cm} (1)

was used, where $r$ is the radius, $D$ is the distance in megaparsecs and $\theta$ is the apparent size of half of the major axis, in arcseconds.

Aperture Photometry Tool (APT) was employed to calculate the apparent magnitude of each galaxy. When available, we manipulate visual band images for calculating apparent magnitude, but empty filter images are used as an alternative when visual band images are unavailable. It is still valid to use empty filter images for visual apparent magnitude calculations because they do not subtract any visual band light out, and all images in APT must be calibrated to nearby stars to produce accurate results anyways. For each galaxy, we select multiple nearby stars to calibrate the apparent magnitude results by measuring their magnitudes in APT and comparing them to published visual apparent magnitude values in the WikiSky database (Wikisky.org). We then use the difference in these values to determine a zero-magnitude constant for APT.

Absolute magnitudes for each galaxy were calculated using the previously measured apparent magnitudes and published distance values. The formula,

$$M_V = m - 2.5 \log \left( \frac{d}{10} \right)^2 - K,$$  \hspace{1cm} (2)

is used, with $K$ as the K correction constant, a value that corrects for comparing sources with different redshifts. Blain et al. (2002) addressed the use of the K correction constant in magnitude calculations and argued that including it does not make a significant difference until redshifts of about 5. Because none of the galaxies in this study have redshifts that exceed 1, we have excluded K

Table 3. Log of Observations

<table>
<thead>
<tr>
<th>Date of Observation (1)</th>
<th>Galaxy (2)</th>
<th>Telescope (3)</th>
<th>Images taken (filters) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 May 2015</td>
<td>NGC 4378</td>
<td>1 m SARA-North</td>
<td>Empty</td>
</tr>
<tr>
<td>30 May 2015</td>
<td>NGC 4594</td>
<td>1 m SARA-North</td>
<td>Empty, Johnson B, V, and R</td>
</tr>
<tr>
<td>30 May 2015</td>
<td>NGC 6314</td>
<td>1 m SARA-North</td>
<td>Empty</td>
</tr>
<tr>
<td>30 May 2015</td>
<td>NGC 2841</td>
<td>1 m SARA-North</td>
<td>Empty, Johnson B, V, and R</td>
</tr>
<tr>
<td>2 June 2015</td>
<td>NGC 4565</td>
<td>0.6 m SARA-South</td>
<td>Johnson B, V, and R</td>
</tr>
<tr>
<td>2 June 2015</td>
<td>NGC 4682</td>
<td>0.6 m SARA-South</td>
<td>Johnson V</td>
</tr>
<tr>
<td>2 June 2015</td>
<td>NGC 4594</td>
<td>0.6 m SARA-South</td>
<td>Johnson B, V, and R</td>
</tr>
<tr>
<td>2 June 2015</td>
<td>NGC 7314</td>
<td>0.6 m SARA-South</td>
<td>Johnson V</td>
</tr>
</tbody>
</table>
correction constants from the calculation of absolute magnitudes. Since luminosity is directly related to absolute magnitude, it was simple to calculate solar luminosities. The formula reads,

$$\frac{L_{\text{galaxy}}}{L_\odot} = 10^{(M_\odot - M_V)/2.5},$$  \hspace{1cm} (3)

where the absolute visual magnitude of the Sun is $M_\odot$.

To calculate stellar mass from luminosity, one needs a stellar mass to light ratio. If no ratio was applied and the luminosity was determined to be equal to the stellar mass, one would be assuming that every star in the galaxy observed is comparable to the Sun in the power of light it emits to the amount of mass it contains. This obviously is not the case, but it is practically impossible to take photometric counts of every star in a galaxy and determine its mass to light ratio, so astronomers have developed other methods of determining mass to light ratios for entire galaxies based on their color. We employ a formula of Bell et al. (2003) with a 0.15 dex adjustment for the Kroupa IMF,

$$\log \left( \frac{M}{L} \right) = (1.305 \times (B - V)) - 0.628 - (0.15),$$  \hspace{1cm} (4)

along with published B-V color indices, to calculate stellar mass to light ratios for each galaxy. Included in the Bell et al. (2003) paper are zero point (y-intercept) adjustments for different published initial mass functions. Because we have assumed the Kroupa IMF for the galaxies, we adjusted accordingly. Once we calculated the ratios using the above formula, we multiplied the luminosity by that factor to arrive at the galaxy’s stellar mass.

As mentioned above, dynamical mass can be calculated with rotational velocity and distance from the center of the galaxy using a rearranged version of the circular rotational velocity formula,

$$V_{\text{rot}} = \sqrt{\frac{Gm}{r}}.$$  \hspace{1cm} (5)

Using published rotation curves, we calculated the dynamical mass of the galaxies using the formula,

$$M(r) = \frac{V_{\text{rot}}^2 r}{G}.$$  \hspace{1cm} (6)

**Statistical Test**

A linear regression test was performed to test for a relationship between gas mass (by percentage) and morphological type. As the value for NGC 4682 appeared to be an outlier, a second test was performed excluding it (Table 4). An adjusted R-squared value was calculated by

$$\tilde{R}^2 = 1 - \left(1 - R^2\right)^{\frac{n-1}{n-p-1}},$$  \hspace{1cm} (7)

where $p$ is the total number of explanatory variables in the model (not including the constant term), and $n$ is the sample size. This adjusted value accounts for the small sample size in this study, and $n$ is the sample size. This adjusted value accounts for the small sample size in this study.

<table>
<thead>
<tr>
<th>Model Value (1)</th>
<th>All data (2) Excluding NGC 4682 (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n$</td>
<td>7</td>
</tr>
<tr>
<td>Predicted slope</td>
<td>0.017</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.0205</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.468</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.063</td>
</tr>
</tbody>
</table>

Table 4. Linear regression models for gas mass content vs. type.

![Figure 3. Johnson V filter image of NGC 7314 taken with the 0.6 m SARA-South telescope.](image)

![Figure 4. Graph of dark matter content vs morphological type. Error bars shown in black.](image)
pears to be an increasing trend in gas content in later type galaxies, NGC 4682 seems not to follow this trend. With all conditions met, two linear regression models were calculated: one inclusive of all the data from the sample and one that ignored the data from NGC 4682. The coefficient of determination greatly increased with the exclusion of the data point from NGC 4682. The second model produces an R-squared value of 0.84, thus 84% of the variation in gas content is accounted for by the morphological type (Table 4). While this is an indicative result, the adjusted R-squared value is a more representative number to explain the strength of correlation because it accounts for the size of our small sample. Still, at 0.63, the adjusted R-squared value shows a moderately strong positive correlation between gas content and morphological type.

We believe that the large deviation seen in the gas content of NGC 4682 is not intrinsic, but rather due to the method used to obtain that value. All other gas mass values were sourced from published papers, but the gas mass value for NGC 4682 was calculated from a proportion given in Young and Scoville (1991). In a survey of 150 galaxies, they also present a positive trend in gas content versus later morphological types. While their proportions do not agree with the data that has been collected with this sample, the similarity of their findings adds validity to this experiment.

Uncertainties were accounted for in the dark matter fractions for both uncertainties found in the published values as well as those calculated from the data taken. We use the absolute uncertainties published alongside the distances from astronomical papers cited.


RESULTS

From the data, there appears to be a decrease in stellar mass content between Sa and Sb type galaxies, apart from NGC 4594 (Figure 4, Table 2). There also appears to be a slight decrease in stellar mass content between Sb and Sc type galaxies, but because of the size of the sample, the significance of this decrease cannot be tested.

We also present the variation of neutral hydrogen gas content as a function of morphological type (Figure 5). Although there appears to be an increasing trend in gas content in later type galaxies, NGC 4682 seems not to follow this trend. With all conditions met, linear regression models were calculated: one inclusive of all the data from the sample and one that ignored the data from NGC 4682. The coefficient of determination greatly increased with the exclusion of the data point from NGC 4682. The second model produces an R-squared value of 0.84, thus 84% of the variation in gas content is accounted for by the morphological type (Table 4). While this is an indicative result, the adjusted R-squared value is a more representative number to explain the strength of correlation because it accounts for the size of our small sample. Still, at 0.63, the adjusted R-squared value shows a moderately strong positive correlation between gas content and morphological type.

We believe that the large deviation seen in the gas content of NGC 4682 is not intrinsic, but rather due to the method used to obtain that value. All other gas mass values were sourced from published papers, but the gas mass value for NGC 4682 was calculated from a proportion given in Young and Scoville (1991). In a survey of 150 galaxies, they also present a positive trend in gas content versus later morphological types. While their proportions do not agree with the data that has been collected with this sample, the similarity of their findings adds validity to this experiment.

Uncertainties were accounted for in the dark matter fractions for both uncertainties found in the published values as well as those calculated from the data taken. We use the absolute uncertainties published alongside the distances from astronomical papers cited.

![Figure 5. Graph of gas mass content percentage vs. morphological type.](image-url)
The relative uncertainties of these range from 0.2% to 1.3%. When using APT to calculate apparent magnitudes, an uncertainty of +/-0.01 mag is adopted because although APT returns values with more than two decimal places, most published values only specify magnitudes to the hundredths place. Therefore, we take 0.01 as an artificial smallest increment for the uncertainty. Lastly, uncertainty in the mass to light ratios was accounted for per the note made in Bell et al. (2003) that “Scatter in the above correlations is ~0.1 dex for all optical M/L ratios...” These uncertainties were propagated through the calculations and are visible as error bars in the figure of the total mass content breakdown (Figure 1).


<table>
<thead>
<tr>
<th>Galaxy (1)</th>
<th>Observed $m_v$ (mag) (2)</th>
<th>Published $m_v$ (mag) (3)</th>
<th>Ref. (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGC 4378**</td>
<td>11.33</td>
<td>11.68</td>
<td>3</td>
</tr>
<tr>
<td>NGC 4594</td>
<td>9.28</td>
<td>9.31</td>
<td>2</td>
</tr>
<tr>
<td>NGC 6314</td>
<td>13.22</td>
<td>13.16</td>
<td>2</td>
</tr>
<tr>
<td>NGC 2841</td>
<td>9.69</td>
<td>9.31</td>
<td>1</td>
</tr>
<tr>
<td>NGC 4565**</td>
<td>9.73</td>
<td>9.58</td>
<td>3</td>
</tr>
<tr>
<td>NGC 4682</td>
<td>13.08</td>
<td>12.31</td>
<td>3</td>
</tr>
<tr>
<td>NGC 7314</td>
<td>11.91</td>
<td>11.01</td>
<td>3</td>
</tr>
</tbody>
</table>

The properties of the Seyfert galaxies in the sample appeared similar to the non-active galaxies for the most part. Although NGC 7314’s gas content fraction was less than half that of the other type Sc galaxy, NGC 4682, we have already pointed out above that the method for obtaining the gas mass value for NGC 4682 was different than the rest of the galaxies, so we do not attribute this to its active nuclei characteristics. NGC 4565 (Seyfert 1) had a comparable gas mass proportion to NGC 2841, another type Sb spiral galaxy, but a significantly lower stellar mass percentage. This is puzzling because Seyferts are noted for their luminous nuclei, which would give a larger stellar mass value. On the other hand, the Seyfert 2 galaxy NGC 4378 produced very similar proportions of gas and stellar mass as the regular type Sa galaxy, NGC 6314 (Figure 1, Table 5).

While we are unable to statistically prove that there is an increasing trend in dark matter content in later-type spirals, the results hint that there may be some authenticity to this relationship that would require further experimentation to confirm.

If this study were to be expanded on, a larger sample of galaxies would make any trends in dark matter or otherwise more apparent. As Calvi et al. (2011) found that environment was a confounding variable that affected the stellar mass-morphological distribution of galaxies, and it is also known that there are multiple correlations between galactic properties and environment (Weinmann et al., 2006), we would recommend sampling from a variety of galactic environments to eliminate this variable in the event that dark matter is also tied to environment. Radio astronomy observations could be performed to gather gas mass data from atomic hydrogen lines as well as rotation curves data to add consistency to the variables.

It is thought that in the early universe, dark matter and gas halos clustered and merged to form spiral galaxies (Coil, 2013). This study provides an opportunity to understand more about the role dark matter plays in the evolution of galaxies. As we discover more information about how different types of spiral galaxies are formed, a trend found between dark matter and galaxy morphology could be useful in predicting the life cycles of spiral galaxies.

**ACKNOWLEDGEMENTS**

I would like to thank Dr. Amy Lovell at Agnes Scott College for her help arranging telescope time at both Kitt Peak National Observatory and Cerro Tololo Inter-American Observatory, her training given on using these telescopes and the software necessary to process the images, and her continual support throughout this process.
REFERENCES


The LGBT Movement Inside the United States Government: Analysing Social Movement Networks in Political Spatialities

Ben Smitton1*

This paper explores the relationship between the Lesbian, Gay, Bisexual and Transgender movement and the United States Government in Washington, District of Columbia. It makes the argument that the LGBT movement has established itself in the political spatialities found in Washington D.C. in order to create pro-equality social reform. The paper identifies a new trend in the LGBT movement whereby the movement uses networks to manoeuvre in political spaces and places to bring about political change. The data used to establish these findings in the research consist of interviews with former and current Members of the United States Congress, Senate and House senior staff and leading LGBT organisations based in Washington D.C. The analysis of the data is presented in three ways: how LGBT movement networks are situated in political institutions, how inter-organisational networks collaborate and how LGBT movement networks move in political spatialities.

INTRODUCTION

New social movements are becoming ever more engaged with the political life of the State and becoming involved with federal governments (Nicholls, 2008; Nicholls, 2009). This research project looks directly at this relationship between social movements and the federal government, through the Lesbian, Gay, Bisexual, and Transgender (LGBT) movement in the United States of America. The aim of this research is to analyse how the LGBT movement utilises and establishes social movement networks in political spaces and places, in order to enable the LGBT movement to create political and social reform which brings about equality for LGBT people. There are three key objectives this research will focus on in order to fulfil this aim.

The first objective is to understand how the LGBT movement situates networks within political institutions and how they work through collective action to create social reform. This involves analysing the LGBT Equality Caucus in the U.S. House of Representatives by looking at its structures, its leadership and the actions the caucus takes to introduce LGBT equality in law-making. The second objective is to discover how the LGBT movement is comprised of a wider network of organisations and activists, and how they form inter-organizational networks and coalitions to advance the movements capabilities so that they can influence the political environment to become more pro-equality. This analysis focuses on how inter-organisational relations create a sharing of resources that strengthen other organisations and allow the movement to access political spaces. The analysis will look at how organisations in the LGBT movement create networks and engage with other organisations to build up pressure on political spaces. The research also investigates how networking with other activist groups can strengthen the abilities of smaller social movement organisations. The second objective focuses on key organisations in the LGBT movement in Washington D.C., which are the Victory Fund, the Human Rights Campaign and the National Centre for Transgender Equality. The third objective is to examine how the LGBT movement manoeuvres through political spatialities so as best to achieve its goals. This involves examining the impact the LGBT Equality Caucus has on the United States Congress and how the LGBT movement has scaled up its efforts to have an LGBT presence in the United States Senate. Moreover, this analysis will examine how Washington D.C. is a city that encourages the LGBT movement organisations and activists to collaborate due to its relational and convergence characteristics. The interviews featured in this re-search are analysed in relation to the academic literature on social movement networks in order to answer these aims and objectives. The qualitative analysis will demonstrate how important it is for social movements like the LGBT movement to engage with political and governmental institutions in order to create social change nationally in the context of the United States.

LITERATURE REVIEW OF SOCIAL MOVEMENT AND NETWORK THEORY

Social Movements

The LGBT movement can be understood through social move-
ment theory and more specifically network theory within that discipline. With regard to the LGBT movement and its relationship with the politics of Washington D.C., there are three key aspects of network theory that need to be understood. Firstly, how networks work internally and how they are structured; secondly, how networks form and work with inter-organisational coalitions; and finally, how networks create and manoeuvre in various spatialities. Social movement theory outlines that movements aim to create a change in wider society and between civil society and the State. In the literature, there is a difference between new social movements and old social movements. Old social movements follow the labor movement whereas new social movements take a different discourse that focuses on “quality of life; equality; individual self-realism; human rights; and democratic participation” (Hetherington, 1998, p. 33). The LGBT movement can be identified as a new social movement because it focuses primarily on the rights of the LGBT community rather than on labor issues and union activism. Network theory can be used to understand how this new social movement goes about achieving these rights and social change for the LGBT community.

Networks & Imagineers

Many geographers have engaged with social movement research through applying network theory in order to analyse and understand the dynamics of social movements and how networks manoeuvre across various spatialities. Activists in social movements can be understood across social movement literature as a network of people who are connected by interpersonal beliefs, causes or political ideologies (Routledge, Nativel, & Cumbersa, 2006). The network can be either informal or formal (e.g. an organization). They consist of relationships and collective meanings which are not just based on shared interests but also shared experiences (Schlosberg, 1999). Bosco (2001) asserts that these relationships “bind social movements and activists strategically and contribute to sustain collective action” (p. 308). The purpose of networks is to build and develop collective action to further advance the causes of that social movement. The relationships between activists are key to shaping collective identity within the network because they further unify commitment to the activists’ core goals (Diani, 2000). Networks, therefore, consist of a united group of people who share political; beliefs, identities, and ambitions, which coalesce around their actions to resolve their inequalities. Bosco’s (2001) research of Madres de la Plaza de Mayo (Argentinian mothers seeking human rights concerning their missing children) analyses these networks and explains how the unity of the network is maintained through emotional bonds which the mothers have in their shared struggle. These shared personal connections of oppression allow the individuals to create solidarities between one another and create and shape new forms of resistance (Featherstone, 2005; Featherstone, 2007). Networks are built up around relationships and common social aspirations.

Social movement networks are more than just relationship connections: they are political action groups. These action groups utilise both social and material resources to achieve their shared mission. By understanding the “socio-material” elements within the network we can recognise how they can become strong actors in space (Müller, 2012). The socio-material elements of a network represent the internal workings of the social movement. Routledge, Cumbers, and Nativel (2007) argue that the internal mechanism of social movements consists of coordination, communication, information sharing, resource mobilization and solidarity. They make the point that political action within networks depends on communication and information exchange, which becomes the source for creating an internal reality. The practical aspects of the network also function alongside the social aspects, particularly shared identities and experiences. The network is ultimately a form of mobilization that is human and material. Networks are seen to independently become an efficient way to pool resources and exchange tactics, ideas and strategies (Schlosberg, 1999). Therefore, the network uses multiple techniques to become active in its political pursuits. The human and the practical apparatus which the network uses is essential for mobilising and creating social change. Analysing the human and material aspects of the LGBT movement will provide a clearer view on the functions of the movement and how it meets its goals.

Networks are also comprised of different structures which influence how the social movement mobilises action and how the movement relates to the activists. There are two main forms of network structure: ‘hierarchical’ and ‘horizontal’. Both can have a major impact on producing political and social change. The hierarchical networks follow a verticalist approach to their operation with formal organisational structures similar to political parties and trade unions where the relations in the network are more centralised around the leadership, and strategies tend to focus on capturing both supporters and power to the cause (Routledge et al. 2007). Nicholls and Beaumont (2004) suggest that hierarchical network structures can be more effective than networks with less formal structures because they have a greater formal capacity to utilise the collective powers of activists, enhancing their capabilities to achieve their goals, which is more difficult to achieve when the network structure is more horizontal. Horizontal structures can still follow Edelman’s (2005) understandings of network structures as open, with the ability to expand and have new actors become integrated into them. This means that an open network structure can create opportunities for enlarging collective action. The type of structure the LGBT movement engages with will establish the basis from which it operates.

Horizontal network structure takes a decentralised approach to networks where there is no direct leadership, instead the focus is on interconnection between activists, the “network strives to create zones of encounter, shared learning and solidarity” (Routledge et al., 2006). Routledge et al. (2006) state that the interconnections within a network are dependent on easily available information, which is a key component for how horizontal structures work. Moreover, there is no singular decision making in these types of networks so they rely on shared decision making processes, with the aim to create “strategic unity” and cohesion (Wolfson, 2013).
This type of decision making puts a greater emphasis on what Nicholls (2008) calls ‘soft infrastructure’, meaning the bonds, ideologies, symbols and relationships the activists experience collectively have an impact on the processes of decision making. The aim of the horizontal network is to establish a system of equal shared authority and participation among activists so that there is no disparity between activists. Whether the network structure is hierarchical or horizontal each social movement needs a structure which is appropriate to the movement and to the social change it seeks to accomplish. Often networks use a mix of both hierarchal and horizontal structures to organise and maintain the network.

No matter whether social movement networks are horizontal or vertical in structure all have established leaders of some sort within the network. Routledge et al. (2007) call leaders in networks ‘imagineers’, particularly networks which are horizontal in structure. These imagineers are either a formal or informal elite which show leadership characteristics of charisma, vigour, commitment and have ability to mould the movement’s philosophies and direction. Routledge et al. (2007) say that the politics of networks are delicate and complicated and that imagineers form a level of cohesion by influencing the construction of the networks identity and set the agenda. These leaders often have to rely on their strong interpersonal relationship with other actors in the network to achieve this. Routledge (2008) states that imagineers are the driving force for the internal culture of the movement because they can delegate roles, enrol other activists and movements and can utilise resources. Routledge (2008) also explains how the way they arrange the relationship between social and material resources have an impact on the effectiveness of the action taken. Therefore, leaders within the network have a significant role and influence of power in the network and can impact the type of outcomes the movement is seeking to achieve. Moreover, imagineers can significantly influence activists and can use their position of power to engage with and mobilise the activists and members of other movements.

Emotion is one such tool they can employ to achieve this. Bos-co (2007) explains how emotion can be used/utilised to activate members of a network towards collective action. He discusses how emotions between activists are shared and influence their collective identities, suggesting that they are an essential part of what makes people relate to one another. Bos-co (2007) argues that these emotional assets can be used strategically to mobilise activists and can be used to create wider coalitions through space. These emotions and grievances are therefore central to social movements because they can establish the movement and can be a driving force for the movement’s momentum, actions and identities (Alexander, Giesen, & Mast, 2006). Leaders have significant social assets such as emotion at their disposal which they can use to move and drive the movement in a certain direction of social change.

**Inter-Organisational Networks**

Networks often expand to form inter-organizational networks where other organizations either within or outside of the social movement join the network or form a coalition with it. Galaskiewicz (1985) highlights three key motivations for these types of collaborations: “resource procurement and allocation, political advocacy and organizational legitimation”. This expansion of network relations can be either formal or informal, but the purpose is to expand the movement’s capabilities by sourcing multiple forms of power through various actors and they unite under common social objectives (Nicholls & Beaumont, 2004). Schlosberg (1999) discusses how the cross-fertilisation of networks and organisations can build bridges across a variety of communities and social causes, which allows for the exchange of diverse information, know-how, expertise, material resources, and loyalty. Moreover, Wang and Soule (2012) highlight how important it is for social movements to be able to transfer important “diverse tactical repertoires” of knowledge, so that social movement organisations can observe and learn from one another. Diani and Bison (2004) make the point that informal networks generally engage in political action collectively as a result of shared identities. Mutual identities can be a benefit in inter-organizational relationships and dissimilar identities can be a hindrance. The key to developing a network with either other entities in the movement or with different actors is to bring them on board in a way that advances the capabilities of the network and creates a wider scope of solidarity.

A social movement which is made up of multiple organisations and various networks have power spread out in the form of a ‘web like structure’, which can create opportunities for developing inter-organisational relations particularly if the web structure is flexible (Schlosberg, 1999). Galaskiewicz (1985) points out that often many organisations have prior relations with each other before forming new coalitions. If this web of organisations and networks consolidates it can engage with the wider political opportunity structures in the landscape. Political opportunity structures can create a need for organisations to collaborate, which in turn will shape the collective strategies of the organisations as they utilise these political opportunities (Nicholls & Beaumont, 2004). However political opportunities are dependent on how open or closed a political system is (Hilson, 2002). If the political opportunity structure is open networks and organisations can place people in or close to state institutions, this has occurred in the LGBT movement in Seattle (Brown, 2008). The strategies inter-organisational networks develop collectively and the sharing resources can be the consequence of being situated in a fluctuating environment where political opportunities may arise or disappear spontaneously. Partnerships, therefore, have to adapt and develop to meet these conditions (Gulati & Gargiulo, 1999). The flow of resources through partnerships, particularly when taking on potentially risky ventures, can be viscous, and so relations need to be dependent on ‘strong ties’ which allow for more durable, long lasting relationships (Rosenthal, Fingrudt, Ethier, Karant, & McDonald, 1985). When coalitions are formed to take on political opportunities they need to be united by bonds of trust in order for campaigns of social justice to be successful.

To create effective outcomes, inter-organisation relationship-building and governance relies on the sharing of people who are professional and are resourceful elites, who are well-placed in
their field of expertise, and who are situated for alliance building (Davies, 2012). This type of networking is dynamic and has an element of risk as potential partners may be unsure about the consequences of forming a coalition and sharing resources (Gulati & Gargiulo, 1999). Therefore, the leaders in the network need to be the ones who steer the outcome of these relations. Leaders or key organisations can take on the similar position to that of ‘brokers’ who engage and bring other networks that are not necessarily associated with the movement into it, making the movement gather strength through diversification of resources and activists (Diani & McAdam, 2003). This type of networking is important particularly if the organisation has limited resources because this type of collaborative networking allows them to become more mobile, adaptable and professionally resourceful. Often these decisions are based on older alliances, meaning these alliances undergo adjustments to form new networks that share information, strategies, resources, personnel, and planning (Gulati & Gargiulo, 1999). Moreover, they set a discourse whereby if new campaigns are formed these alliances and network connections can be called upon if necessary and can be adapted once again.

**Network Spaces & Places**

Networks that interact across places, spaces and scales do so through social relations. The social movement network itself is intrinsically spatially relational in its character given that activists themselves build connections with one another. Routledge et al. (2007) refer to these spaces as ‘zones of encounter’. Ward, Pickering, MacKinnon, and Featherstone (2010) understand relational spaces as open and in the process of becoming, through actions of actors in networks. Relational spaces and places are more fluid in their form of politics, where unified action is dependent on the relationships and connections individuals or organisations build between one another, this collective action can also create new forms of spatial politics (Davies, 2012). These political spaces can become spaces and places of contentious politics where dominant political discourses and positions of authority are challenged by these forms of collective action, which consequently produce an alternative form of politics which is counterhegemonic (Leitner, Sheppard, & Sziarto, 2008). Leither et al. (2008) also make the point that places and spaces of politics both shape and are shaped by social movement actions. They state that places and spaces where politics is carried out are layered with power and meaning which activist networks can utilise to their advantage and create new spaces of solidarity. Activists develop relations and build collective action in order to challenge the power discourses of certain spatialities. By changing the politics of that place they can create the social reform that the social movement aims to achieve.

Social movements build networks and relations across scales from the local, to the state, to the national and the international, in order to tap into the power, the scales hold by establishing new power relations or oppose existing ones (Leitner et al., 2008). Nicholls and Beaumont (2004) explain that social movements move across spatial scales so that they become more effective in achieving their goals, which they implement by making adjustments to the positionality of the network or their strategies. Nicholls and Beaumont (2004) make the suggestion that social movements are rescaling their activities to governmental levels, that strategies are not just focused on lobbying the political elites but establishing networks within the circles and administrative duties of political elites. They label this as ‘reterritorialisation’. It is a social movement strategy that involves claiming spaces through instituting new forms of socio-political order and power onto the environment and consequently reverting the dominant discourses of that space (Miller & Nicholls, 2013). This involves building support among powerful actors where they become part of the social movement. Often this means networks establishing themselves in strategic cities which have political institutions where grievances can be heard and where the pivotal branch of the network can be established and can gather tactical resources (Nicholls, 2011). Social movement networks are realising the benefits of advancing their positionality in space, to be located in places of political advantage to them.

Davies (2012) states how strategic cities have become important places for social movements to situate themselves because of the ever increasing embeddedness of state and non-state institutions. These types of cities create opportunities for social movements to establish networks in these structures given the potential value that could be gained from these institutional bodies. Academic Walter Nicholls has undertaken work on understanding social movement networks relationships with strategic cities. He states that some cities have structures of power that foster relations between a variety of social movement organisations as well as with political institutions, which can consequently benefit social movements (Nicholls, 2008). He calls this type of city a “relational incubator”. This incubator encourages relationships between multiple activist groups and institutions, whose political causes at times may overlap (Miller & Nicholls, 2013). However, the degree to which networks benefit from this relational incubator is dependent on how much they make an effort to integrate. Nicholls (2009) expands the idea of networks being situated in relational cities and spatialities, stating firstly that different groups with similar objectives can connect, and secondly that power can be resisted or reinforced through collective action. Places that foster relational space are important to networks in terms of how they work collectively with other actors and how they operate in strategic settings. Understanding “relational incubators” is important for analysing the LGBT movement as it establishes how the movement operates and functions in political places and spaces.

Paul Routledge (2000) expands the idea of networks functioning in relational space through his concept of “convergence space”. Convergence space is where different actors can unify their collective actions and “generate a politics of mutual solidarity” where various organisations work together in a way where the philosophy of one interest group is not predominant over the rest (Cumbers, Routledge, & Nativel, 2008). Routledge (2000) states that it is a space of “facilitation, solidarity, communication, coordination and information sharing”, a space that has strategic significance for a range of interest groups and a space in which they
can develop commonalities. McFarlane (2009) states how placed-based social movements have similar connections to ‘convergence space’ because they involve the “exchange of ideas, knowledge, practices, materials and resources across sites”, which he states is achieved through leaders shaping collective action. Convergence spaces do, however, develop complex linkages between the various activist nodes, which means convergence space does have an unstable element to it. This complexity is the result of the dynamics of actors working through differences, relations and compromises; these dynamics are the result of convergence space being a forum of negotiation (Routledge, 2003). Convergence space has a mixed form of ‘operational logics’ in its structure where the networks operate through a hybrid of both the horizontal and vertical structures, which influence the negotiations and how imagineers go about organising convergence space (Cumbers et al., 2008). Imagineers are the people who bring groups together and establish new campaigns in these spaces of convergence. Convergence space is the places, spaces and scales in which multiple groups negotiate their differences and similarities, and form a collective vision. Convergence space allows social movements to develop, a concept by which LGBT movement can be understood more effectively in relation to.

The LGBT Movement

The LGBT movement has embraced a variety of strategies throughout its history that aim to create equality for all LGBT people through court cases, political lobbying, protests and direct action (Hilson, 2002). Stone (2010) explains how the LGBT movement has evolved to become more professionalised with formal organisations. Bernstein (2002) makes the point that in the case of the Gay and Lesbian movement (that later became the LGBT movement) identity politics and its fixed associations have played a strong role in the movement. The LGBT movement was born out of the sexual revolution of the 1960’s. The 1969 Stonewall riots in New York City are seen as the hallmark of the movement and since then its causes have changed quite dramatically (Brown, 2008). The movement developed from purely focusing on equality and identity toward considering health issues, in response to the 1980’s Aids epidemic which was stigmatised as a ‘gay disease’ (Smelser, Wright, Baltes, & Langlois, 2001). Today the LGBT movement is continually changing and can be seen to be having a significant role in the national politics of the U.S.A. This section will examine these political changes and specifically how the movement is situating itself in American Politics, specifically through applying network theory outlined above. The discussion below demonstrates that the LGBT movement uses networks in political spatialities to create equality for LGBT people. Network theory is the most appropriate for this analysis because it deals with the complex linkages and structures that are found in social movements. Discovering how social movement networks use political spaces to create social change is something which has not been investigated in social movement geography research before. The rest of this paper speaks to this intellectual gap.

METHODOLOGY

The opportunity arose for this research project to be carried out when the researcher undertook an internship working for United States Senator Tom Harkin [D-IA] from January to May of 2013. After presenting the research proposal to Senate colleagues and seeking advice and support from them the researcher was able to undertake the data collection. The data is comprised of nineteen interviews which included: former and current Members of the United States Congress (shown in the acknowledgements); Senate and House chiefs and deputy chiefs of staff; the executive director of the LGBT Equality Caucus; Senate and House Congressional legislative staff; and directors in The Human Rights Campaign, The Victory Fund and the National Centre for Transgender Equality. Accessing these high-profile interviews involved using a variety of strategies, primarily relying on snowballing. Snowballing, in which “informants refer the researcher to other informants, who are contacted by the researcher and then refer her or him to yet other informants and so on”, allowed the researcher to accumulate significant amounts of data (Noy, 2008). In the preliminary stages of gathering the research data this involved writing letters directly to the openly LGBT Members of Congress and LGBT organisations asking them to interview, but unfortunately this technique yielded a low percentage of replies. The most successful way for the researcher to recruit interviewees was through developing key contacts at the U.S. Congress that found the research project interesting and who were able to introduce the researcher to senior staffers in different congressional offices and lobbyists at LGBT organisations. The GLASS (Gay Lesbian & Allies Senate Staff) caucus was particularly helpful in building these connections. The caucus is a non-partisan network of gay, lesbian and bisexual staff at the Senate that supports staff with professional development, social networking and employee welfare. Moreover, the researcher’s position of working for Senator Harkin was an advantage due to the Senator’s outstanding efforts to support the LGBT community and people with disabilities. Coming from a Senate office with such a high reputation enabled the researcher to be seen in a positive light by other congressional offices. These multiple factors enabled the researcher to ascertain interview data from a variety of highly valuable sources. These sources are the most appropriate and relevant for this research project because they include a range of key stakeholders in the national political aspect of the LGBT movement.

Semi-structured interviews were the most appropriate method to collect the data, which was recorded on an audio device and then transcribed. This method was ideal because of the time constraints many of the interviewees were under, particularly the Members of Congress. Due to these time constraints the researcher needed to be alert during the interviews and well prepared so that the most useful questions were asked, as well as being flexible and encouraging interviewees to develop informative points. Semi-structured interviews have an arrangement and purpose that makes room for development, but it is also important that the interviewer is aware of power relations (Hemming, 2008). The researcher had
to be aware of power relations because some of the interviewees were elected officials which meant ensuring these dynamics were an advantage to the research and not a limitation. All participants signed a letter of authorisation which assured them that their data would not be used outside of this project and would not be passed onto the press. The research was carried out ethically by not including information that is politically sensitive and ensuring that the data would not cause controversy once published. This also included contacting some participants asking their permission to include certain sensitive information in the research project. Meth and McClymont (2009) demonstrate that researchers must be respectful and trustworthy with their participants and must put in place the necessary infrastructure to do this, which this research project carried out.

In order for the research to be fully informative of the LGBT movement in the political sphere of the United States the researcher followed the latest developments and reporting on LGBT issues and participated in the movement’s activism. This formed a background participation observation whereby these activities were recorded in a field journal in order to provide a context for the interview data. This participation observation followed Laurier’s (2010) understanding of this method as having ‘no pre-set formal steps’ and instead focusing on the opportunities presented in the research field. The timing of this research was undertaken at a pivotal point in the LGBT movement during the hearing of Supreme Court cases on the Defence of Marriage Act (DOMA), which discriminated against gay married couples receiving federal benefits in the United States, and the California Proposition 8 case, involving a ban on gay marriages in California through a state constitutional amendment. This created momentum and national talk about the LGBT movement. During this time the Human Rights Campaign organised protests outside the U.S. Supreme Court, which the researcher was able to participate in. This was an informative opportunity to learn more about and experience the LGBT movement in the U.S. Moreover, it enabled the researcher to understand the context in which the research was being undertaken.

The qualitative analysis for the project consisted of coding the nineteen interviews to identify the key themes emerging in the data. The contextual information enabled a background of clarity for these themes. This data was then synthesised and analysed in relation to the academic literature on networks and social movements. This qualitative analysis was the most effective way to gain a real understanding of the use of networks in the LGBT movement; how they operate in political spatialities; and how they create social reform.

RESULTS

The analysis and discussion focuses on the three key objectives of the research. Firstly, the analysis and discussion will look at understanding how the LGBT Equality Caucus is situated and functions as a social movement network. Secondly, it will discover how key organisations in the LGBT movement gather strength from each other and develop networks in order to advance the LGBT cause. Thirdly, it will examine how the Caucus, openly gay Members of Congress and LGBT organisations move through places and spaces of politics.

The LGBT Equality Caucus Network

The LGBT Equality Caucus in the U.S. House of Representatives can be identified as a network of elected Representatives who are either LGBT activists or allies, who aim to promote and support legislation that benefits the LGBT community. The caucus was founded in 2008 by former Representative Barney Frank [D-MA] and the then Representative, now Senator, Tammy Baldwin [D-WI], who were the only two openly gay Members of Congress at that time. Since then it has evolved and expanded and is seen to have both a mix of hierarchical and horizontal operational structures. At a first glance the caucus network appears to be verticalist, where a formal leadership is the central component to the ongoing activities of the caucus and where the aim is to widen participation and increase its power capabilities (see Routledge et al., 2007). Similarly, the structure of the caucus network can be viewed as an open structure as described by Edelman (2005), so that different actors can join the network and it can expand. The LGBT Equality Caucus works as a formal hierarchical structure where the six co-chairs oversee the activities carried out by the caucus. They disseminate information about those activities and mobilise support from the vice-chairs and the other members of the caucus. The changing pace of the LGBT equality movement has created an atmosphere where the caucus leadership can use the expanding membership of the caucus to bring more support to LGBT legislation (see following quotes). The caucus’s structure supports Nicholls’ and Beaumont’s (2004) idea that hierarchical network structures are more effective for mobilising and using the collective powers of activists because the leadership of the network is the driving force behind this momentum. The caucus co-chairs can create this effect in the network, particularly when there is a piece of LGBT legislation going through the House or when LGBT issues are being debated in national politics.

“We have a very very strong LGBT Equality Caucus that gets even stronger with every Congress. Last Congress we had four openly gay members, now we have six co-chairs, we have a number of straight vice-chairs and we have even more member’s. But really on the democratic side in particular these Members [of Congress] are flocking to be a member of the Equality Caucus to support and drop bills, even before us on gay issues. I think in large part a lot of people in Congress view it as the final civil rights issue of our time” (Scott Fay – Chief of Staff; Congressman David Cicilline [D-RI] 27/02/13).

“I think it’s [LGBT Equality Caucus] going to be one of the largest caucuses in all of Congress, more people who want to join it as regular members not as co-chairs will, the co-chairs have to be openly gay, vice chairs don’t have to be openly gay but they want to support the caucus at the higher level…. if you look back five years ago that would not have been the case” (JoDee Winterhof –
The formal formal of the LGBT Equality Caucus is the central feature that allows the decision making and functionality of the caucus to work through a hierarchy. This paper argues that the six co-chairs do not just exist for the purpose of leadership within the caucus, but that they are a network themselves of committed LGBT activists that work as a horizontal collective group to push the LGBT movement’s agenda forward. They carry out all the primary work of the caucus including sharing equal and collective responsibility for it and are viewed by people as both representing and embodying the caucus. These six Members of Congress have organised and pulled their resources together to move their goals forward, which has included recruiting an executive director. The six members work on a horizontal level sharing duties, decision making and leadership, in the same way as Routledge et al. (2006) and Wolfson (2013) describe horizontal power structures. They are able to unite through what Nicholls (2008) calls the ‘soft infrastructure’ because they are the only openly gay Members of Congress and therefore can connect to the LGBT movement directly. This horizontal leadership approach creates what Wolfson (2013) states as ‘strategic unity’, were the LGBT activist present a strong image of leadership to the rest of Congress. 

The LGBT Equality Caucus has the core elements of a network which Schlosberg (1999) defines as interpersonal experiences, shared relationships and collective meanings between activists, all of which according to Bosco (2001) drive the social movement. All the caucus members unite around this need to help the LGBT community because it is regarded as the “final civil rights issue”. However, for the caucus leaders it is something much deeper and personal because they are part of the LGBT community.

“Well there’s a term that is used in politics, authentic representation, and it goes something like this; few people will care about issues as deeply or as committedly as someone who is actually of the community that is here for it, not to represent it” (Congressman Mark Takano [D-CA] 09/04/13).

“I think the biggest thing that many of us often say is that it gives you a seat at the table, so often decisions are made about people but not by the people involved and having your seat at the table ensures your voice, your unique voice is heard on issues that affect the LGBT community” (Congressman Mark Pocan [D-WI] 09/04/13).

The six co-chairs and their personal experiences which they bring to the political discussion are life stories that relate to the experiences of LGBT people and to the movement. It is what unifies these openly gay Members of Congress. It gives them a purpose in legislating for equality and it allows them to collectively form interpersonal solidarities. This follows the argument that the identities which the movement possess are the result of resistance struggles which form solidarities between activists that then help build and constitute collective action (Featherstone, 2005; Featherstone, 2007). Their interpersonal connections are then formulated into their goals which aim to use legislation to overcome injustices that the LGBT community face (see next quote). The caucus’s goals become the political purpose that the network aims to fulfill and these goals are shaped by the collective gay identities and experiences of the co-chairs. This supports Diani’s (2000) idea that shared relational identities support collective action and strengthens the activists’ commitment to their aims.

“Well our priorities are: the repeal of DOMA [Defence of Marriage Act] which I think the court will do and if they don’t I think we should do it [U.S. Supreme Court repealed DOMA on 26/06/13]. ENDA [Employment Non-Discrimination Act] to assure that you can’t be fired for being gay or Lesbian. We are working hard to assure uniting Americas families, which is an immigration provision that is included in the comprehensive immigration to protect gay and lesbian families. And then there is a lot of legislation around bullying and making sure schools are safe places for kids, so that no child, because of their sexual orientation or any other reason is bullied or feels unsafe at school. So those are kind of the four key areas.” (Congressman David Cicilline [D-RI] 17/04/13).

The six co-chairs are not just the key activists in the LGBT caucus but they are the caucus’ imagineers who use their collective qualities and skills to shape and drive the movement in the political space of the United States Congress and also as leaders of the LGBT Movement nationally. The caucus leaders have set an agenda for building a united front for LGBT equality in Congress through using their different legislative backgrounds and positions in Congress with the aim to bring more people on board (see next quotes). The imagineers have been building the caucus to become a strong force of leadership in the House by taking their roles as leaders in the LGBT community seriously and using their power in the caucus and in their roles in Congress to bring LGBT issues to the table. These LGBT leaders follow Routledge et al. (2007) and Routledge (2008) pattern of what makes network imagineers as they have used their qualities to shape the direction of the caucus and to become a greater voice for the LGBT community. Their agenda is to make this network a stronger force for equality, which has consequently shaped the forms of action the caucus takes.

“The goal is to have it [LGBT Equality Caucus] be a real force of leadership in the House. So in the House we have the Congressional Black Caucus, the Congressional Hispanic Caucus and Congressional CAPAC Caucus [Congressional Asian Pacific American Caucus] and they are considered to be real leaders on the issues that impact their members, and we want to be that for the LGBT community” (Anonymous Congressional Staffer – LGBT Equality Caucus Legislative Assistant 27/02/13).

“In addition having six members we are able to be on a broad variety of committees and so in almost any type of discussion, at least on the democratic side of the isle there is a member of the...
LGBT community in the room on many many different issues, and of course many issues affect the LGBT community.” (Congressman Jared Polis [D-CO] 10/04/13).

“They need to be strong responsible figures that demonstrate that they are here to represent millions of people in this country who are gay or who have family members who are gay, or friends who are gay and I think that they all take this responsibility seriously… all six of them and Tammy of course in the Senate” (Scott Fay – Chief of Staff; Congressman David Cicilline 27/02/13).

The LGBT Equality Caucus is a political action network which has its own internal workings allowing the co-chairs (and to an extent the wider membership of the caucus) to pool resources and use strategies and tactics to achieve the goals and objectives of the caucus, in the same way that Schlosberg (1999) outlines. The caucus network has to implement Müller’s (2012) mechanisms of “sociomaterial” resources that are both human and non-human. The caucus relies on non-human resources as outlined by Routledge et al. (2007), such as providing information to other Members’ offices and legislative expertise on LGBT issues which they provide for both the caucus members and the wider membership of the House. This involves making the caucus accessible to other members by being resourceful and providing them with briefs on LGBT issues, so that members become enlightened on these debates (see next quotes). The Violence Against Women’s Act demonstrated how this political action network can internally coordinate its material resources to become a political force that impacts other legislators to support their aims of social justice for the LGBT community.

“There are three primary functions; one is to help coordinate the LGBT related activities of the six co-chairs, second aspect is to do outreach and education with the general membership of the House. I think there are people who are generally supportive of LGBT issues and more people are becoming more supportive of marriage. Beyond the big ticket items like Respect for Marriage Act, repealing DOMA, Employment Non Discrimination Act and HIV Aids issues, people don’t understand a lot of the nuance of the community and the issues that impact a lot of our families and our members. So the caucus wants to do more outreach and more education with the general membership [Members of Congress] to get them to understand what the community faces on a day to day basis, what their lived experience is” (Brad Jacklin - Executive Director; LGBT Equality Caucus 10/04/13).

“So like the Violence Against Women Act that we are considering this week has an LGBT component, so we try to get involved on that bill and we make ourselves available to the other offices if they have any question about our views on that legislation” (Anonymous Congressional Staffer – LGBT Equality Caucus Legislative Assistant 27/02/13).

“I think in the Violence Against Women Act we were a constant presence in making sure the LGBT provisions stayed in it. And the fact that they [Republican majority] had to come and get Democratic [minority] votes meant we could hold those provision in the bill, and I think that was a success. So even though we are not a majority here we can still have that impact.” (Congressman Mark Pocan [D-WI] 09/04/13).

Another important factor is that the imagineers in the caucus can deploy their human resources to mobilise the network and the wider social context, so that people become engaged with the LGBT movement. For the caucus human assets (e.g. imagineers themselves) are important particularly for mobilizing people to the LGBT cause. When the caucus first started it was much smaller and it was necessity for it to be driven by human resources. Congressman Barney Frank and Congresswoman (Senator) Tammy Baldwin were able to use their different personalities and styles to build relationships with Members of Congress particularly on the democratic side, which was necessary to gain support for the LGBT cause. The Matthew Shepard and James Byrd, Jr. Hate Crimes Prevention Act of 2009 is an example of how the caucus was able to use real emotion to engage democratic Members of Congress to vote for this bill. Congressman Barney Frank was able to share his personal experience about how he was afraid to come out and how deeply he feels for LGBT youth that are afraid today and for the people who are vulnerable to hate crime. His emotive speech allowed Members of Congress to see a different personal side to him. Also the caucus invited Judy Sheppard to speak about the death of her son Mathew Sheppard who was murdered for being gay, as well as the police chief who investigated the death. Both were able to emphasise the importance of protections for vulnerable people. Grievances and emotions which are central to social movements as Alexander et al. (2006) point out, were used by the LGBT Equality Caucus to mobilise people within and outside of the caucus to vote for this bill and to be part of the LGBT movement at this point in time. The caucus demonstrated Bosco’s (2007) idea that human resources can be used in a strategic way through activating emotion to help the movement become real for others, so that they can be mobilised for social change.

**LGBT Social Movement Inter-organizational network**

The LGBT Equality Caucus works with and relies on collaborating with other organizations in both a formal and informal way, which creates a wider inter-organizational network of organizations in the LGBT movement. The Victory Fund has a very formal relationship with the caucus’s six co-chairs because these Members of Congress depend greatly on the Victory Fund for their election campaigns. The Victory Fund’s connection to the caucus is for resource procurement which Nicholls and Beaumont (2004) and Schlosberg (1999) state as increasing social movement capabilities through the exchange of material resources and knowledge, with the aim to achieve similar objectives and goals. The Victory fund aims are very similar to the caucus as they seek to have authentic representation of the LGBT community in Congress and across
public life in the United States. These similar organisational identities support Diani and Bison’s (2004) suggestion that shared identities encourage collaborations. To achieve their collective goals, the Victory Fund supports LGBT people who are running for office to overcome the barriers they face, which is often running in an area where the socio-cultural atmosphere is not as understanding of queer issues (see following quote).

“There are a lot of barriers for gay or straight people to run for office. You don’t get paid a lot so you have to have a financial situation where you can afford a home here and a home in your home state. You have to have a family situation that’s appropriate and you have to not have a lot of skeletons in your closet, gay or straight. Where it matters for gay people running for office, is the district or the state that they run from. Tammy Baldwin winning in Wisconsin is huge! But not every state would lend itself at this point in time” (Tom Lopach – Chief of Staff; Senator Jon Tester [D-MT] 09/03/13).

The Victory Fund seeks to overcome these barriers by supporting candidates with election finances, training them on how to run a campaign and overcome any opposition regarding their sexual orientation (see next quotes). The Victory Fund activates their activist network to make campaign contributions to the various candidates and link campaigns up with donors, which is important because campaigns need large sums of money e.g. Congressman Takano’s campaign. In addition, the Victory Fund’s campaign support is strategically and tactfully helpful for candidates giving them the tools for a good election campaign. The six co-chairs of the caucus and Senator Baldwin were able to utilise the resources and knowledge that they needed from the Victory Fund. A network connection was formed between the candidates and the Victory Fund, which created what Wang and Soule (2012) state as a collaborative exchange of a “diverse tactical repertoire” of knowledge, ideas and resources. This inter-organisational relationship is important for the LGBT movement because it allows them to sustain their presence of having authentic representation in political spaces, particularly in the U.S. Congress. The Victory Fund has supported the LGBT Equality Caucus and the six co-chairs with Galaskiewicz’s (1985) three key reasons for collaboration: campaign finance (resource procurement), legitimate LGBT candidates (political advocacy) and more elected Equality Caucus leaders (organizational legitimation).

“The key takeaway from Victory Institute’s [branch of the Victory Fund] training is that your campaign always has to be focused on the voters, it has to be focused on the things they care about. Let’s say you are openly gay and you’re running for office in Tulsa Oklahoma, not being a hot bed of gay activism or gay rights. Imagine, let’s say the top issues in that city are crime, the environment and the schools, if those are not your issues as a candidate you will be in trouble because you’re not really speaking to the concerns of the people who will be hiring you” (Denis Dison - Senior Vice President for Programs; Victory Fund & Institute 11/04/13).

“The Victory Fund primarily activates their downer and grassroots network. So the victory fund staff takes a look at the candidate and looks at viability; are they running a good campaign, do they have support not just within the LGBT community but outside, do they have the requisite experience, do they have a good story, are they doing the things a modern campaign needs to do to win” (Tiffany Muller - Vice-President of Political Operations; Victory Fund & Institute 15/03/13).

“Fundraising was a unique challenge. For Mark’s campaign, one of the ways which being openly gay was helpful was that it connected him on a very real level with a lot of donors that we might not have otherwise been able to reach” (Richard McPike – Chief of Staff; Congressman Mark Takano [D-CA] 28/03/13).

The Human Rights Campaign (HRC) is another part of the LGBT movement network web in Washington D.C. which works with the LGBT Equality Caucus, and lobbies the other Members of Congress in the House, the Senate and the Obama Administration. They run a full-service lobby shop for Members of Congress including constituent letters, speeches, research, expert advice, legal work and bill-writing. However, much of their work is building up networks of coalitions between other organizations, people and social movements in order to build pressure on these political institutions. Part of what HRC does is identifying what Nicholls and Beaumont (2004) call political ‘opportunity structures’ and mobilise their networks to engage with them. This involves HRC adapting to these new opportunities as they arise in the political landscape so that they can take full advantage of them, in the same way as Gulati and Gargiulo (1999) express.

A clear example of when HRC has used multiple networks to create political pressure and build up a case for reform was through encouraging President Barack Obama and the White House Administration to support gay marriage. They saw that there was a political opportunity in the Administration through the 2012 presidential election. The President’s re-election campaign was facing a lack of enthusiasm from the LGBT community because he had not come out for gay marriage, which isolated them from the LGBT community as a key voting and fundraising block, which is a factor that could be significant in the swing states. Also the legal arguments and briefs the administration would have to make over LGBT related legal cases were an issue. HRC put significant amounts of their resources into arguing the case for coming out for gay marriage to the White House (see next quote). Moreover, they invested in building a wider network of large businesses across the country that were signed onto supporting gay marriage politically. This network of companies that support gay marriage was another tool in which they could show how the nation stance on this issue was changing. Also HRC were able to utilise the wider network web of social movement organisations to gain more resources, particularly one organisation called Third Way who produced research on the dynamics of talking about coming out for gay marriage politically. Their research suggested that coming out for gay
marriage publicly should be spoken from a position of ‘evolving’ on the issues, coming to a new understanding and talking from the perspective of being on a journey. This type of discussion means that voters who are unsure about this issue can see the individual’s process for supporting gay marriage and can appreciate their decision without necessarily agreeing with them. Using this information from Third Way and building a network of support meant they could utilise this opportunity more and engage with President Obama and the Administration encouraging them to come on board with supporting gay marriage. This action follows Brown’s (2008) analysis of social movements putting pressure on state institutions including having people and organisations situated close or within those places. This demonstrates how HRC has taken hold of an opportunity in the political landscape and has called on its network and developed new networks of support with engaging with this opportunity in a strong influential way. The Obama Administration in this case can be seen to be what Hilson (2002) calls structural openness in the political system, at this point in time with regard to LGBT rights. Furthermore, HRC’s action here follows Gualati and Gargiulo (1999) ideas of social movements adapting to changing political opportunities in the political environment.

“Yes we met with the administration and we also had people who both knew him [President Barack Obama] on a personal level and fundraised for him, who were asking him to come out for gay marriage. Lots of meetings, lots of pressure, lots of messaging and lots of research. We did lots of polling, much of which we shared with the White House. At the end of the day in came down to a political call but it was inevitably an intellectual and legal issue. The timing was a political calculus but I don’t think the outcome was. I think the President wanted to do it, but they were looking for the right opportunity and sometimes when you’re looking for the right opportunity you never decide. It started to get late and they had to make the decision. They may or may not have spilled it too soon” [President Obama came out in support of gay marriage 09/05/12] (David Stacy - Government Affairs Director; Human Rights Campaign 04/04/13).

In the LGBT movement inter-organisational networks and relations have been crucial for the Transgender part of the movement. They have had to develop what Rosenthal et al. (1985) and also what Davies (2012) states as ‘strong tie’ relationships with resourceful elites who are well placed in order to be productive in creating their social reform that is specific to the transgender community. Transgender rights and equality is similar to the lesbian, bisexual and gay part of the movement, but there are a lot of distinct issues (e.g. gender identity cards) that specifically effect this smaller segment of the LGBT community and therefore they need their own organisations like the National Centre for Transgender Equality (NCTE). NCTE has seven staff and an annual budget of $600,000 and therefore cannot rely on direct lobbying of the U.S. Congress and the Administration, particularly on issues that they are not a major player (e.g. immigration reform) even though these issues still affect transgender people (see next quotes). Therefore, NCTE has to be more strategic by being engaged with the wider LGBT social movement network and align with the more resourceful elite organisations like HRC and the LGBT Equality Caucus in order to bring Transgender issues to the table by uniting them with lesbian, gay and bisexual issues. They have to engage with their older LGBT alliances and adapt them according to the new issues and campaigns of the day. The entrepreneurial qualities NCTE utilises with how they use the resources they possess and share follows Gualati and Gargiulo (1999) and Galaskiewicz (1985) point about how social movements have to evolve from alliances in the wider social movement network. NCTE acts in a similar way to Diani and McAdam’s (2003) idea of a broker, because NCTE has to have other groups and partners include transgender issues in their work or have them become involved with NCTE’s work in order to strengthen their voice. This demonstrates how important the wider web of social movement organisations is for smaller activist groups.

“We work to amplify the message of partner organisations and our allies, so we join coalitions and if folks are working on things we will try to amplify their voice. Right now the LGBT movement really has a lot of power, it has a lot of sizzle. We have become a really important voting block and a really important campaign funding block, so everybody notices us now. So if we can make something an LGBT issue like immigration we can really bring some weight to bear on it”

“Lobbying wise, very little of what we do here is lobbying, we do some lobbying, but generally the lobbying we have to do because we have such as small budget is much smarter lobbying. We can’t pay twenty lawyers to wine and dine a Senator. So instead we find close allies who are well placed within a particular issue area and brief the heck out of them and really rely on partners in other organisations, partners who are legislators and other partners to pull a lot of the weight when we are trying to get something done” (Mara Keisling – Executive Director; National Centre for Transgender Equality 08/03/13).

The LGBT Movement’s Political Spatialities

The LGBT Equality Caucus can be seen, as Routledge et al. (2007) describe, as a ‘zone of encounter’, a space situated in a wider political context of the U.S. Congress. The caucus is a relational zone that can create new forms of counter-hegemonic spaces in the same way as Davies (2012) describes network spatialities. The caucus is relational in the way that Ward et al. (2010) define relational space as being open and in a process of ‘becoming’ through actors. The LGBT Caucus is dependant not only on its internal relational connections but also on connections with Members of Congress outside of the caucus. The Congress itself is a relational place that is dependent on representatives joining forces with one another not just within their political party but outside of their parties, so that they can push through legislation. The caucus becomes an apparatus for the LGBT movement to reach out, particularly through the six co-chairs (see next quotes). They are able to engage with this
relational aspect of congressional space to bring support from various political associations to the LGBT movement. The co-chairs take on the role of brokers, outlined by Diani and McAdam (2003) as people who bring on board others who are not necessarily associated with the movement. The LGBT caucus members use their own personal abilities to engage other Members of Congress on these issues. The caucus is therefore a counter-hegemonic spatiality which acts as a resistance to the discourses of the straight, white male and middle-class hegemonic politics, in that it offers an alternative politics of inclusiveness and equality. This follows Leitner et al. (2008) arguments that powerful places can be challenged and new spaces of solidarities formed which consequently reshape the wider spatial context, for example Congress progresses to become more pro-equality. This demonstrates how important it is for the LGBT movement to engage with political spaces in a relational way so that they can accomplish the social reform they want.

“Basically maybe one out of five hundred bills go to the House floor, 499 never get voted on. The way you get a bill voted on is by getting more cosponsors, particularly cosponsors from both parties, until you have such a number that it’s clear to any Majority Leader that a majority of the House supports it. So I would think for instance if we can get 220 to 230 cosponsors for the Student Non-Discrimination Act we can supply significant pressure to Leader Cantor [House Majority Leader Eric Cantor R-VA] to bring it to the floor of the House” (Congressman Mark Pocan [D-CO] 10/04/13).

“The presence of the LGBT movement within national political institutions can be seen to be a ‘reterritorialisation’ of political spaces of power in order to set new power relations by establishing the movement at these higher scalar levels (Leitner et al., 2008; Nicholls & Beaumont, 2004) which challenges anti-LGBT opposition. The LGBT movement has done this successfully by creating and expanding the LGBT Equality Caucus in the U.S. House of Representatives, but now they are also focusing on scaling its presence in the upper chamber the U.S. Senate. The Victory Fund invested a substantial amount of money and resources in the 2012 election of Senator Tammy Baldwin [D-WI]. They really energised their donor network and the wider LGBT community and organizations to elect the first openly gay U.S. Senator. It is important for the movement to have members of the LGBT community present at different scales of the U.S. Government, so that they can make an impact in those places. Particularly in the Senate where Senators have a lot of independence from the political party stances, which is less so the case in the House. Having the presence of an openly gay person in the U.S. Senate particularly Senator Baldwin who co-founded the LGBT Equality Caucus changes the dynamics of the Senate. Her presence puts more pressure on the Republican Senators who follow an anti-LGBT rhetoric (see Levensale quote). Also having Senator Baldwin creates an opportunity to bring support into the LGBT movement as well. The Senate is experiencing a shift in LGBT politics particularly on the Republican side (see Kolbe quote), which could be the influence of the presence of an openly gay colleague and the positive changing climate toward the LGBT rights movement. There is a steady move towards the acceptance of LGBT rights by Republican Senators and this is having an effect on the legislative environment and on law-making. The LGBT movement’s investment in gaining access to this powerful higher scale political institution could be seen to be following Miller and Nicholls (2013) understandings of social movements as movements that make ‘claims’ on space, which challenge the symbolic and political order of that environment and in this case also challenging ideologies and beliefs of political parties.

“Senators now have an openly gay colleague that they have never had before and she is so regular and normal, intelligent and friendly, she will change hearts and minds. And I think that’s the most important thing, is how she will change, one on one change her colleagues’ perceptions of gay people” (Jeffery Levensale – Deputy Chief of Staff, Senator Tammy Baldwin [D-WI] 28/03/13).

“Trying to assure equal rights for same sex couples in immigration reform legislation was a major thrust of the LGBT community when this legislation was being considered in the Senate. It’s interesting how quickly Republican thinking on this issue has evolved. One Senator quite conservative just shrugged when we raised the issue in a meeting. He said the issue is going to be gone in a few years, that the fight over equality is basically over.”

“That’s not to say there won’t be lingering problems of acceptance of equal rights for LGBT couples particularly in certain geographic regions of the country or with certain groups. But for most people associated with Congress Members and staff it is a ‘non-issue’ now. Certainly, I didn’t find anyone who thought inclusion of equal immigration rights would be a “deal breaker” for the reform legislation.” (Congressman Jim Kolbe [former Representative: R-AZ] 18/04/13).

Washington D.C. can be “conceived of as a ‘relational incubator’ because it facilitates the building of networks among diverse activist groups” (Miller & Nicholls, 2013, p.460). Washington D.C. and the LGBT movement within the city follow Walter Nicholl’s theories (Nicholls, 2008; Nicholls, 2009) of cities as spaces where creative collective action between organisations is formulated for advancing social movement goals or campaigns, in order to engage with State institutions. The LGBT movement has taken
advantage of the relational characteristic of Washington in order to mobilize the movement. Washington can be seen as having greater relational characteristics for new social movements than other cities because it is the most politically powerful city in the world and it attracts a large number of social movement and NGO organizations. With reference to Nicholls (2011) this therefore defines Washington D.C. as a ‘strategic city’. The Human Rights Campaign is a clear example of utilising this relational incubator to form a greater powerful force of collective action over the wider social movement and political space (see next quote). By coalescing other social movements (situated in D.C. and across the USA) into the LGBT movement’s causes they are able to build up momentum and a stronger base of support. One example of this is the Hate Crimes Prevention Act, where collective support was transcended into Washington’s political spaces in order to make reform happen. They are able to do this not just because of the relational characteristics of Washington D.C. encouraging multiple groups to join forces but also because of the increasing embeddedness between the movement and the state institutions, which supports Davies (2012) understandings of the characteristics of strategic cities.

“We do lots of coalition work to support those efforts, for example on the Matthew Shepard and James Byrd, Jr. Hate Crimes Prevention Act we had over 300 non-profit organisations that supported passage of the legislation from religious groups to police organisation and other law enforcements; so you know the National Sheriffs Association, the National Association of Police Of-fices, the Unitarian Universalists, the Presbyterians and religious organisations. As well as civil rights groups like the NAACP [National Association for the Advancement of Colored People], or the National Disability Rights Network. So we had a very big cross-section of support. And women’s groups the American Asso-ciation of University Women and the National Council of Jewish Women. So we do coalition works to bring lots of people to the table.” (David Stacy - Government Affairs Director; Human Rights Campaign 04/04/13).

Washington D.C. can be understood as being and containing spaces of ‘convergence’ for the LGBT movement and other movements, as these activist groups collaborate and create spaces of solidarity (Cumbers et al., 2008). This is a space where the LGBT movement and other movements can coordinate, exchange knowledge and support one another in their ventures, as compared with Routledge (2000). This is similar to McFarlane (2009) place-based understandings of social movements of networks that exchange resources, however the LGBT movement is more similar to convergence space because it’s not limited to just Washington D.C., but operates nationally gaining support from other activists and movements across the country. For example, HRC uses its own organisational structures to mobilise its network of 1.3 to 1.4 million activists and its steering committees in about 30 different cities, which they are able to mobilise at key strategic times. Washington D.C. acts as a hub where convergence of social movements and their participants particularly the LGBT movement can be organised and be more effective in engaging with the national political apparatus. Collective action in convergence space is highly dependent on the leaders of those organisations uniting without one ideology being predominant which involves them negotiating the dynamics of forming collective action (Routledge, 2003; Cumbers et al., 2008), this is something the LGBT movement has done well both within and outside of political spaces.

CONCLUSION

The analysis and discussion of the data has explored how the LGBT movement utilises and establishes social movement networks in political spaces and places to create pro-equality social reform. Networks like the LGBT Equality Caucus and the inter-organisational network linkages used by the Victory Fund, HRC and NCTE have clearly utilised and scaled their resources and efforts to create an LGBT movement presence in political places and spaces, through engaging with the relational and convergence qualities of those spatialities. This access and networking has increased the capabilities of the LGBT movement to have a real and profound impact on LGBT-related legislation, and has arguably advanced equality for millions of Lesbian, Gay, Bisexual and Transgender Americans.

The LGBT Equality Caucus is the most profound example of how the LGBT movement has situated itself in a political institution of the U.S. Federal Government, through establishing a network of people organised through both hierarchical and horizontal structures. This network and its leadership are able to unify around the inequality found in the LGBT community and then transcend these issues in to political spaces by being part of the discussion and having the community’s unique voice at the table. The leadership of the caucus are particularly able to have this impact due to their interpersonal connections and bonds. Moreover, this network is able to bring together its collective forces and can implement both human and material resources to mobilise action for bringing LGBT reform into legislation. It is evident that the imagineers of the caucus (namely the six openly gay co-chairs) are the profound influence and driving force for bringing the LGBT movement to Congress. The LGBT Equality Caucus represents the importance of having an organised LGBT voice within political institutions.

The wider network of organisations and activist groups that make up the LGBT movement and the coalitions that are formed between them have had a real impact on influencing the political environment. The Victory Fund has done this effectively by using their resources to support the campaigns of openly LGBT candidates that are running for Congress. They assisted in overcoming barriers that LGBT candidates face enabling them to become elected so that there is an authentic presence of the LGBT movement in Congress. Moreover, LGBT advocacy organisations have established new networks of solidarity and have engaged with other social movement organisations to build pressure on political institutions. HRC has done this effectively, encouraging President Barack Obama to ‘come out’ for gay marriage. Influenc-
The political landscape is ever-changing, providing opportunities for the LGBT movement to engage more effectively in political spaces across the United States. The LGBT Equality Caucus has been a key player in this process, acting as a platform for political engagement that is open to all LGBT individuals. By encouraging external voices to join, the Caucus has been successful in increasing the community's presence in political conversations and decision-making processes. This has been particularly evident in the recent election of Tammy Baldwin to the Senate, which has had a significant impact on the movement's ability to influence legislation.

The Caucus has also been influential in promoting the idea of a ‘relational incubator’ and a ‘convergence space’ where different movements can come together to form the basis of future political action. This has been particularly important in states like Arizona, where anti-LGBT sentiments are strong, as a way to counteract the dominant narrative and build a stronger foundation for future political change.

Moreover, the Caucus has been recognized for its role in political reform, with the election of Tammy Baldwin seen as a significant milestone for the LGBT movement. The Caucus's efforts to engage with political spaces have been instrumental in achieving these victories, and its successes have provided a model for future movements to follow.

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REFERENCES


World’s First CRISPR Clinical Trial

Young Joon Kim, Columbia University

Oncologist Lu You’s research group at Sichuan University injected a patient with CRISPR modified cells on November 15, marking the first time CRISPR gene-editing has been tested in a human. The team delivered modified cells into a patient suffering from aggressive lung cancer as part of their clinical trial at the West China Hospital in Chengdu. The study stands as a key milestone in the CRISPR revolution, which began in 2013 with the discovery of CRISPR’s genome editing potential.

CRISPR, which stands for Clustered Regularly Interspaced Short Palindromic Repeat, are short, repeated sequences of palindromic DNA that are found interspersed throughout bacterial genome. In between these CRISPR sequences are “spacer” sequences, which are portions of viral DNA that have been replicated and stored from prior viral invasions. When a virus attacks bacteria that contain matching “spacer” sequences, a RNA transcript, called CRISPR RNA, of the corresponding “spacer” sequence is constructed from bacterial “memory.” Finally, a delivery protein lines up the CRISPR RNA and the foreign viral DNA and either cuts up or modifies the latter, forming an immune response.

Laboratories and hospitals can use this immune machinery to edit DNA of any species. One can construct CRISPR RNA that corresponds to a gene of interest then let the efficient and accurate CRISPR delivery system identify the gene and either modify or disable it. The potential for CRISPR-based treatment in treating genetic diseases, including various cancers, has become apparent in the past few years of the CRISPR revolution.

Gene-editing therapies, other than those that rely on CRISPR, have recently been applied to human patients with astonishing success. In November 2015, Immunologist Waseem Qasim of Great Ormond Street Hospital for Children NHS Trust in London successfully treated a one-year-old girl with leukemia by injecting her with T-cells that were extracted from a healthy donor and edited with another DNA-cutting protein called a TALEN. CRISPR’s main advantage over existing gene therapies stems from its relative affordability, efficiency, and ease-of-use, which makes it an attractive option for physicians around the world.

Using CRISPR, Dr. Lu You’s team removed immune cells from the patient’s blood and disabled a gene that codes for the protein PD-1, which normally suppresses a cell’s immune response. Cancers such as leukemia have been known to take advantage of immune system inhibition by PD-1. Then, the researchers re-injected the edited PD-1 disabled cells into the patient, hoping that the uninhibited immune cells would overwhelm the malignant cells.

Although Dr. Lu You’s study marks the first time CRISPR has been utilized to treat human patients, various other CRISPR clinical trials will begin in the coming months and years. The National Institute of Health (NIH) approved the United States’ first CRISPR clinical trial at the University of Pennsylvania under the leadership of Dr. Edward Stadtmauer. The study revolves around a similar strategy to that of Dr. Lu You’s project: modifying and injecting healthy T-cells into patients with leukemia. Likewise, similar trials have been recently approved for bladder cancer, prostate cancer, and renal carcinoma at Peking University.

Aware of the enormous therapeutic potential CRISPR harbors for patients with cancers and other genetic diseases, clinics in the US and China are racing to bring CRISPR to the forefront of human medicine. Dr. Carl June, who is involved in the aforementioned study at the University of Pennsylvania, states: “I think this is going to trigger ‘Sputnik 2.0,’ a biomedical duel on progress between China and the United States, which is important since competition usually improves the end product.” Although CRISPR-based treatments have made enormous progress since their inception only a few years ago, it seems more investigation is necessary in order to fully harness the power of CRISPR.

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Lessons from the Lab Bench

Daniel Bernstein, George Washington University

Undeniably, admissions committees prioritize a few select factors in considering applicants for scientific PhD programs. Foremost among them are previous research experience, matching interests with research groups, and undergraduate coursework. After three years of undergraduate research, I have received my fair share of advice on positioning myself for graduate school from colleagues, advisers, and friends. I would like to take a moment to articulate some of the most important insights, some of which I heard from others, but more often I had to find out for myself.

DIVERSITY

Independent research predominates the graduate student experience. Four to six years of work towards a singular, overarching goal is not for everyone. My first research adviser recommended I treat undergraduate research similarly, and devote at least two years to his research group to complete a small project and demonstrate my dedication to graduate schools. I agree that it often requires more than a single semester to master laboratory techniques and fully grasp conceptual underpinning. Only then, with both a technical and theoretical understanding, can undergraduates evaluate whether a subfield is a good match for their graduate work. However, extended stays in a single group prevent students from exploring various research areas and developing flexibility to translate their skills between fields and adjust to new environments with ease.

After a year of biochemistry work with this advisor, I began considering trying my hand at synthetic organic chemistry. I was told that I would not be able to find a research position in organic chemistry because my technical skills were limited to biochemistry. To his credit, I did not receive a single offer for summer undergraduate research programs after my sophomore year. I took the summer off, then enrolled in an experiential learning course while studying abroad at University College Dublin, where I learned synthetic techniques under the tutelage of a graduate student in an organic chemistry research group. While this experience was not a true research assistantship, this introduction to the field was enough to launch me into a new field; the following summer I received numerous summer research offers from prestigious institutions. Since making this transition, I have carried out research in organic chemistry research groups at Georgetown University and the University of Cambridge.

This diverse array of research experiences has been invaluable towards my personal development as a researcher and an individual. Experiencing four research groups, ranging in size from four to twenty-five, each with different structures and capabilities, endowed me with a better understanding of my preferences in research settings and made me more versatile. I have no doubt that leaving my first research position has made me happier and given me a more well-rounded view of research by exposing me to more academics and graduate students. Students are not bound to commit to the first research area they investigate, and only through exploring different environments and research groups can they make an informed decision about their research interests and ambitions.

MENTORSHIP

Graduate students often point to a strong, personal connection with their adviser as the deciding factor in entering one graduate program over another. Research advisers, beyond providing technical expertise, become close mentors, providing guidance as students transition into graduate studies and then into post-doctoral work. Likewise, research advisers are unmistakably the most valuable resource for undergraduates as they consider their career goals, seek out summer research opportunities, or prepare for graduate school.

However, what happens when graduate school is no longer the goal? Or, a research adviser is aloof and difficult to get to know? It is equally important to develop close relationships with mentors apart from research advisors. These individuals, be they classroom professors, professional supervisors, or academic advisers, can offer unparalleled insight into various career paths and often are more than happy to share their wealth of experiences. While research advisers are often apt to push their students towards research careers, outside mentors often provide more objective assessments and provide different perspectives in how they challenge students to consider their goals. I have especially enjoyed my discussions with my thesis advisor, the chair of my university’s English department, because he asks open-ended questions and creates a non-judgmental atmosphere that allows me to articulate my thoughts at length in ways I had not previously considered. Other mentors are more confrontational and force students to come to terms with thoughts and feelings that students might not be ready to admit to themselves.

REFLECTION

Between coursework, research, extracurricular activities, and finding time for friends and family, there is often little time to reflect on our research experiences and place our decisions in context. It is too easy to think that students should go into graduate studies because they have been involved in undergraduate work for several years. Bringing together diverse experiences and having mentors that ask the right questions help students reflect on their undergraduate work and make plans for their future. I would suggest students, especially those considering graduate school, con-
sider some of the following questions that I have found essential for my own development:

**What are the daily tasks in your research and can you find them in other activities?**
I love working with my hands to turn starting material into new product. But as my interest in a career in chemistry has waned, I discovered an emerging passion for baking; I now have a recreational outlet for the same skills that will continue as I transition into a different field.

**Do you love doing the chosen research or are you fascinated with the results?**
Students often conflate what they like thinking about with what they like doing. The daily toil in research is rout with failure. While the potential for new therapies and technologies is captivating, students need to consider whether they enjoy the daily tasks enough to commit to long hours with a narrow research scope, or whether they care more for applying new treatments in real-life settings, for example as a clinician or public health official.

**Does the research and the career outcomes directly relate to the larger contributions you hope to make in life?**
The two main career trajectories after scientific graduate studies are academia or industry. In considering these outcomes, students need to assess how they feel about working in those environments and if those careers match their personal goals and desired contributions. While there is opportunity for young professionals with technical backgrounds in consulting, government, or non-profits, there are likely other pathways apart from a technical PhD to reach similar outcomes. Devoting four to six years in graduate research should serve as a clear stepping stone towards larger ambitions to warrant the commitment.

Taking the opportunity to work in various research groups through summer research opportunities yields insight into student’s preferences in work environment and gives students the opportunity to talk about career paths with graduate students, post-docs, and professors during formative years. Finding mentors who can offer diverse backgrounds and mentoring styles help probe a student’s thoughts as well as wrestle with difficult decisions. Taking the time to reflect on how various choices integrate into a larger personal narrative is essential for bringing together diverse experiences and mentorship as students make important decisions concerning their future and where they find meaning.
Meet Our Distinguished Authors

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Elliott Williams is a sophomore in the Honors Program at the University of Georgia studying Physics and Astronomy. Elliott wrote his first published paper as a high school senior using observations taken with telescopes in Arizona and Chile. This summer, he will again work with telescopes in Chile, but this time in person at an internship with the Cerro Tololo Inter-American Observatory. Elliott works in a lab at the University of Georgia, using supercomputer simulations to study turbulent clouds in the Magellanic Stream, a large structure orbiting the Milky Way galaxy. He plans on presenting this work at the American Astronomical Society conference in Denver, Colorado in the summer of 2018. Elliott lives in Athens, GA with his dog, Kenna, and two roommates.

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Ben Smitton studied at the University of Birmingham for his undergraduate degree ‘Geography with Year Abroad’, achieving a First Class Bachelor of Science degree with Honours. During his year abroad study at the University of Iowa in the USA, he undertook an internship working at the U.S. Senate where he carried out his dissertation research about the LGBT Movement within American politics, which now features in the JYI Journal. The research was also awarded the Nick Wellings Prize in Geography by the University of Birmingham. Since leaving academia Ben has gone on to work in the charity sector at Groundwork an environmental charity, where he runs a community grant funding programme on behalf of one of the UK’s leading retailers Tesco. In his spare time he volunteers on the board of directors for Age UK (Brighton & Hove), which is the UK’s leading charity for the elderly.

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