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The Biological Bases of Political Attachment: Neurobiological Correlates of Ideology and Partisanship

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THE BIOLOGICAL BASES OF POLITICAL ATTACHMENT: NEUROBIOLOGICAL CORRELATES OF IDEOLOGY AND PARTISANSHIP

by

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ABSTRACT

THE BIOLOGICAL BASES OF POLITICAL ATTACHMENT: NEUROBIOLOGICAL CORRELATES OF IDEOLOGY AND PARTISANSHIP

by

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To fully understand the foundations of political attachments in an increasingly polarized environment, political scientists must reconcile traditional theories of political attitudes and behavior with insight gained from neurobiological approaches. The purpose of this research is to investigate the neurobiological correlates of strength of political ideology and partisanship, as well as the neurobiological correlates of ideological and partisan orientation. To do so, both structural and functional neuroimaging analyses were conducted on a diverse sample of patients at a Level 1 Trauma Center. Results indicate that strong ideological attachment is significantly associated with decreased volume in the left insula, though partisan attachment is not. Functional neuroimaging did not reveal any significant differences in neural activity during an emotion regulation task between strong and weak ideologues or partisans. In examining the neurobiological differences between liberals and conservatives or Democrats and Republicans, structural analyses revealed no significant differences, while functional analyses demonstrated a positive and significant relationship between Republicanism and neural activity in the right inferior parietal lobule in the reappraise condition of the task. Taken together with extant biopolitics literature, these studies indicate a need for additional neuroimaging work in the field of political science.

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LIST OF ABBREVIATIONS

ACC	Anterior Cingulate Cortex
BOLD	Blood Oxygen Level Dependent
CAPS-5	Clinician Administered PTSD Scale for DSM-5
FWE	Family-Wise Error
IPL	Inferior Parietal Lobule
ISS	Injury Severity Score
ITSS	Injured Trauma Survivor Screen
MNI	Montreal Neurological Institute
MOI	Mechanism of Injury
MRI	Magnetic Resonance Imaging
MTOP	Milwaukee Trauma Outcomes Project
PCL-5	PTSD Checklist for DSM-5
PTSD	Posttraumatic stress disorder

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Chapter One: Introduction

Introduction

"The origin of the human condition is best explained by the natural selection for social interaction—the inherited propensities to communicate, recognize, evaluate, bond, cooperate, compete, and from all these the deep warm pleasure of belonging to your own special group." E.O. Wilson, The Meaning of Human Existence

Throughout his influential body of work, sociobiologist E.O. Wilson advocated for a biologically based concept of human nature: that is, the human propensity to behave in a particular manner and to establish social organizations. According to Wilson, human nature is the product of evolutionary and hereditary mechanisms which have led to the development of complex, hierarchical social structures (Wilson 1975). While social scientists readily accepted an evolutionary basis for the behavior of animals like primates or ants, extending the process to humans was initially controversial. However, in the decades since *Sociobiology*, the foundational components of Wilson's theory of human nature have been empirically tested, supported, and incorporated into most fields within the social sciences.

Still, in some areas, scholars remain reticent about integrating biological constructs into traditional models of social behavior. Political scientists are particularly reliant on Durkheimian convention, focusing primarily, if not solely, on external societal factors. This is not surprising, since the political science agenda was first influenced by the behavioral revolution of the mid-twentieth century, and later by the economic theory of rational choice. Neither of these approaches encourages the incorporation of individual-level biological analyses. It was not until the 1970's that political attitudes were measured with respect to human psychophysiology or neurobiology (Sperry, Zaidel, and Zaidel 1979; Wahlke and Lodge 1972), and more years would pass before Eaves and Eysenck demonstrated the heritability of social attitudes (Martin et al. 1986).

Despite the success of these early "biopolitics" studies, standard models of the formation of political attitudes and behavior continue to point to only the influence of social forces. Parental socialization, childhood environment, socioeconomic factors, and political institutions are repeatedly cited as drivers of political attitudes and behaviors, including whether people will be liberal or conservative (Jennings, Stoker, and Bowers 2009; Kent Jennings and Niemi 1968). Biological factors are generally perceived as contradictory to these classic explanations and are summarily ignored.

To move forward with a complete and accurate theory, political scientists must reconcile traditional theories of political attitudes and behaviors with the biological underpinnings of human nature. More research is necessary to replicate and bolster empirical findings demonstrating that the basic components of human biology are relevant to social attitudes broadly, and political attitudes more explicitly. Settled research questions must be reexamined: From where do political attitudes and behavior originate? Are political attitudes socially determined? Novel research questions must also be asked: How do neurobiological structures and functions differ between political ideologies? Under what conditions do genetics exert an influence on political attitudes?

With the marked increase in political polarization during the past several decades, it is increasingly important to investigate the biological bases of not only the directionality of political orientations, but also the variation in degrees of ideological and partisan attachment (e.g., extremism). There is reason to believe that one's strength of ideological or partisan affiliation may have served an evolutionary purpose, yet few studies have examined this directly. Though there are clearly biological differences between liberals and conservatives or Democrats and Republicans, there may also be relevant neurobiological distinctions between political extremists and political moderates. Given the practical implications of political polarization in American society, defining the biology underneath attitudinal and behavioral phenotypes is overdue.

In this chapter, I first describe the theoretical support for a biological conceptualization of political attitudes and behavior; namely, political ideology and partisan affiliation. I then review the current state of neuropolitical and genopolitical research related to political attitudes before turning to a discussion of the hypotheses and methods of this dissertation. I seek to further our knowledge of biopolitics by examining the neurobiological distinctions between extreme and moderate political orientations. Political moderates are compared to those with strong political affiliations in terms of both structural and functional neuroanatomy. Neurobiological distinctions are also analyzed with respect to the more traditional comparison of liberals and conservatives, or Democrats and Republicans. Through these analyses, I hope to contribute to the still-burgeoning literature on biopolitics, encouraging others to examine the biological mechanisms underlying our political divisions.

Ideological and Partisan Attachment

Political scientists frequently report the many ways in which liberals and conservatives or Democrats and Republicans differ beyond issue positions or vote choice. Artistic tastes, cultural preferences, metacognition and learning styles, seeking novel information, confidence, mood, and social behavior are only a few examples of the non-political correlates of political ideology and partisanship (Hibbing, Smith, and Alford 2014; Zmigrod et al. 2021). Ideological and partisan differences have also consistently been found to mirror variation in other psychological organizing constructs like personality (Caprara et al. 2006) or values (Schwartz 2007). For example, self-placement on a liberal-conservative spectrum and reported partisanship are strongly associated with authoritarianism (Adorno et al. 1950), as well as the Big Five personality traits of conscientiousness, agreeableness, openness to new experiences, extraversion, and emotional stability (Jeffrey J. Mondak 2010). Values like conformity, tradition, power, and universalism are also robustly related to ideological and partisan orientations (Schwartz 2007).

One pervasive finding is that liberals and conservatives differ in their psychological and physiological response to negative stimuli. This “negativity bias” has been repeatedly shown to be stronger among conservatives when compared to liberals, both in terms of the amount of attention directed toward negative stimuli and having a greater reaction to negative stimuli (Amodio et al. 2007; Hibbing, Smith, and Alford 2014; Pedersen, Tugan Muftuler, and Larson 2018). More specifically, conservatism is associated with increased attention toward negative words or images, and ambiguous faces are more often perceived as angry among conservatives than liberals (Vigil 2010).

Liberals and conservatives also react differently to disgust, a primitive survival emotion. Conservatives report a higher likelihood of self-reported disgust than liberals and have higher involuntary physiological responses to disgusting stimuli. Even controlling for the degree to which respondents believe they are sensitive to disgust, conservatives show more reaction to disgusting stimuli (Smith et al. 2011). It is clear that liberals and conservatives and Democrats and Republicans differ in not only behavioral outcomes, but also in subconscious physiological responses to stimuli. These mechanisms are automatic, outside of conscious control, and unmonitored (Jost, Sapolsky, and Nam 2018).

Why do divisions in political ideology translate onto so many non-political traits? At its most basic, political ideology is a system of beliefs. These systems of beliefs are surprisingly consistent across cultures and over time; ideological distinctions appear to be both primeval and ubiquitous (Jost 2006; Jost and Amodio 2012). Though the contemporary political ideology labels of right and left are often attributed to the French Revolution, the foundational liberal-conservative distinction is considerably older (Noel and Therien 2008). This is because political ideologies are thought to encapsulate broader ways in which people organize their beliefs and behavior, and politics is simply one domain in which individuals apply these divisions. Simply put, there is a general human psychosocial division that is manifested in differences in political ideology. Thus, ideology can be studied in terms of its form and structure, rather than solely the content of its context-specific beliefs (Zmigrod 2021).

For example, divisions in political ideology have been historically characterized as favoring either tradition and stability, or innovation and reform (Hibbing, Smith, and Alford 2014). Groups favoring tradition and stability resist social change and prefer a maintenance of the status quo, while groups favoring innovation and reform challenge the status quo and push for progress. These differences are often coupled with a second dimension of distinction pertaining to perceptions of inequality. On one side, inequality is accepted, and the hierarchical nature of social systems is maintained. On the other side, inequality is rejected, and the hierarchy is directly confronted (Jost et al. 2014). This intrinsic difference in human preferences is then applied to myriad specific circumstances or issues, producing a sense of attitudinal coherence. The universality of an ideological division, and its robust relationship to traits of evolutionarily importance, provide ample evidence for a biological basis for human variation in political orientations.

While the concept of ideology is distinct from partisanship, there is a great and growing degree of concordance between the two groupings and many studies treat them interchangeably. Like ideology, partisanship is a salient and meaningful social identity. Instead of reflecting basic divisions in ideological orientation, partisanship denotes affiliation with a major political party. Partisan distinctions often mirror ideological ones, with empirical studies demonstrating a multitude of psychological and value-based differences between Democrats and Republicans. For example, Republicans have been found to be higher on extrinsic values like money, popularity, and image than Democrats, but lower on measures of prosocial values (Sheldon and Nichols 2009). Studies have even identified differences between Democrats and Republicans in the language used on social media platforms like Twitter (Sylwester and Purver 2015). Republicans focused more on religion, national identity, and in-group identity and their opponents, while Democrats utilized more emotive verbiage, and focused more on entertainment and culture than politics (Sylwester and Purver 2015).

Despite the current concordance between ideological and partisan group attachments, extant literature suggests that there may be evolutionary differences in the relevance of these distinct political groupings. Most notably, in a twin study investigating the potential for a genetic basis of partisan affiliation, findings reveal that the genetic influence on party identification was minimal in comparison to environmental influences (P. K. Hatemi et al. 2009). In fact, including genetic factors when modeling partisan affiliation yields no improvement in model fit. However, the same study found that the majority of specific political attitudes are influenced by genetic sources at least moderately, and one's intensity of partisan affiliation is genetically influenced as well (Hatemi et al. 2009). Thus, while the direction of partisan affiliation is not genetically based, the intensity of partisan affiliation does appear to have an evolutionary role. Based on this study, it is important to test the roles of ideological and partisan group attachments separately. It is possible that while biological differences will be present between ideological groups, they are not between partisan groups.

Strength of Ideological and Partisan Attachment

Perhaps as a result of the proliferation of empirical studies demonstrating robust differences between liberals and conservatives or Democrats and Republicans, the ways in which individuals within these groups may be *similar* is often overlooked. Specifically, political extremists within both conservative and liberal ideologies and both the Democratic and Republican parties may share biological and psychological similarities when compared to political moderates or the politically apathetic. The fact that liberals and conservatives or Democrats and Republicans differ on many dimensions does not preclude the possibility that extremists of either orientation also share commonalities. For example, there may be an underlying proclivity towards strong group affiliation common to both ideological and partisan orientations. It is important to note that in this application, political extremism refers exclusively to one's strength of ideological or partisan attachment; "extremism" is not necessarily indicative of the ideological placement of an individual's issue positions on a left/right spectrum. Political extremists who report a strong attachment to a conservative ideology or the Republican party may not subscribe to far-right political beliefs, and extremists who report a strong attachment to a liberal ideology or Democratic party may not subscribe to far-left political beliefs. It is the *strength* of ideological or partisan attachment that is argued to be related to evolutionary biological purposes.

One theory that could help explain the propensity to hold an extreme attachment to a political group is the uncertainty-identity theory, which predicts that self-uncertainty yields a higher strength of social identification, even with "radical" groups (M. A. Hogg, Meehan, and Farquharson 2010). This theory is situated within the broader theory of social identity (H. Tajfel and Turner 1979; Henri Tajfel 1970). Social identity theory characterizes group affiliations as affectively based psychological attachments that powerfully shape an individual's identity, altering perceptions of the world and providing a sense of belonging. Social identification derives from the psychological motivation for positive distinctiveness, and it is the foundation of both in-group favoritism and out-group hostility (H. Tajfel and Turner 1979; Henri Tajfel 1970). From an evolutionary perspective, social identity (*e.g.*, group membership) is critical to foundational human needs such as safety, survival, and cooperation.

According to the uncertainty-identity theory, members of both liberal and conservative ideologies or Democratic and Republican parties may identify more strongly with their political groupings in order to reduce uncertainty (M. A. Hogg, Meehan, and Farquharson 2010). People generally attempt to reduce feelings of uncertainty, especially self-uncertainty, and knowing one's place in a social structure can help protect against this negative psychological state. This theoretical approach explains why, broadly speaking, strength of membership in any social group may be dependent on individual variation in coping strategies for uncertainty.

More specific to the political environment, the extremism hypothesis offered by van Prooijen et al. (2015) proposes that political extremes at both ends of the spectrum are more likely to display "rigidity of the right" in combatting fear and uncertainty. Rigidity of the right explains conservativism as a form of motivated social cognition wherein conservative attitudes are derived from a need to dispel of feelings of fear and uncertainty. To fight fear and uncertainty, conservatives are known to hold attitudes of resistance to change and a desire for structure or order (van Prooijen et al. 2015). While empirical research has consistently shown that conservatism is more strongly associated with an intolerance of uncertainty than liberalism (Jost et al. 2003; Tetlock 1989), this alternative perspective argues that the psychological motive to reduce uncertainty, fear, and threats can be equally applied to the possession of strong ideological or partisan beliefs in either direction (Greenberg and Jonas 2003; van Prooijen et al. 2015). That is, the desire to reduce fear and uncertainty in the social environment is not only characteristic of right-wing ideologists or Republicans; it is instead shared by extreme ideological and partisan members on both the left and the right. Notably, whether one identifies strongly with a political ideology or party under conditions of uncertainty is likely to be dependent on underlying biological differences.

The extremism hypothesis suggests that some of the same evolutionary mechanisms that influence conservative tendencies will also drive strong attachments to either political orientation or party. This area of evolutionary overlap does not negate the clear differences between liberals/conservatives and Democrats/Republicans; rather, it introduces a quadratic relationship between group membership and response to fear or uncertainty. It is also important to note that while the psychological basis for strong attachment among liberal Democrats or conservative Republicans may be the same, the two groups are not equivalent and are not expected to behave in a similar manner. Strong Republicans will still act differently than strong Democrats, notwithstanding the shared psychological goal of avoiding fear and uncertainty.

Numerous historical and empirical examples exist to support the idea that both liberals (Democrats) and conservatives (Republicans) seek to reduce fear and uncertainty (Greenberg and Jonas 2003). For example, black and white thinking and categorizing solutions into good or bad is common to both ends of the political spectrum (Toner et al. 2013). Political extremes of both the left and right are also entirely convinced of their correctness (Toner et al. 2013). These conclusions support the idea of compensatory convictions, in which feelings of uncertainty or fear are correlated with increases in ideological certainty (Mcgregor, Prentice, and Nash 2013). Studies have also revealed that traditionally “conservative” principles like prejudice or intolerance are common among strong adherents of either side of the political spectrum

(Brandt et al. 2014; Chambers, Schlenker, and Collisson 2013; Crawford and Pilanski 2014; Wetherell, Brandt, and Reyna 2013), though the target is often very different.

Along the same lines, van Prooijen and Krouwel (2019) show that psychological distress stimulates the adoption of more polarized ideologies among both liberals and conservatives, which stems from anxious uncertainty and a sense of meaninglessness. Research supports this supposition by demonstrating that both left and right extremists report strong levels of anxiety, particularly about their economic futures (van Prooijen et al. 2015). In conjunction with psychological distress, these authors also stipulate that extremists at both ends of the political spectrum can be characterized as cognitively simplistic, overconfident, and intolerant of others (van Prooijen and Krouwel 2019). These shared cognitive approaches and a selective attention toward fear and uncertainty are undoubtedly associated with specific biological mechanisms, which may be apparent through neuroanatomical or genetic differences when compared to political moderates.

Evolution and Attachment

Traditional theories of political science stipulate that social learning is the primary mechanism for the transmission of political attitudes and behaviors. Social learning describes the process through which familial or cultural mores, patterns, customs, and practices shape the attitudinal and behavioral repertoires of its members (Bandura 1969). According to Bandura (1969), children learn by observing, modeling, and imitating the attitudes and behaviors of others, which makes learning an inherently social activity. Social learning also extends to identificatory outcomes, which is particularly relevant in the political context. Children are presumed to observe, model, and imitate the political identifications of their familial or broader societal environment.

The significant correlation between parental and offspring political orientations is widely believed to indicate that the primary source of transmission is parental socialization (Campbell et al. 1960; Hyman 1959; Tedin 1974). Herbert Hyman (1959), for example, acknowledges the importance of other sources of social learning, but emphasizes the preeminence of family in both the direct and indirect shaping of children's political orientations. Early on, other scholars challenged the impact of familial social learning, citing a variation in correspondence between parents and children in idiosyncratic attitudes, and instead pointed to other socializing agents like school (Torney and Hess 1965). Still, the strong correlation between parental and offspring political orientations provides empirical support for the argument that the transmission of political attitudes and behaviors are learned, and the childhood acquisition of political orientations determines the character of adult political development (Jennings, Stoker, and Bowers 2009).

Ignored within this research is the possibility that the political correspondence between parents and their children is not the direct result of social learning, but rather, the indirect result of biological inheritance. While genetic studies of political attitudes have reported the heritability of issue positions on taxes, nuclear power, and other specific attitudes (P. K. Hatemi et al. 2010), proponents of political socialization argue against a biological explanation and question the validity of these approaches. Some criticisms, particularly of specific methods like twin studies of genetics, are worth considering, but other critics reject the idea of a biological model of political attitudes altogether.

In general, evolutionary explanations of attitudes and behavior, whether political or not, recognize that the human brain has evolved functionally specialized mechanisms over time (Tooby and Cosmides 1995). These mechanisms are the result of adaptations through natural selection and are functionally specialized to produce behavior that solves problems. Importantly, "every feature of every phenotype is fully and equally codetermined by the interaction of the organism's genes…and its ontogenetic environments" (Tooby and Cosmides 1995). So, while humans share a universal biological architecture with content-specific mechanisms, these mechanisms respond to environmental contexts which produces variation in attitudes and behaviors.

Perhaps the strongest case against a biological and evolutionary based explanation for political attitudes and behaviors among political scientists concerns the relative recency of mass-scale politics. In the span of human evolution, large-scale political organization is indeed a notably recent phenomenon, and genetic and physiological changes occur over expansively long periods of time. It also appears to be uniquely human, as no social organization in primates or other mammals corresponds to human political behavior (Knutson et al. 2006). Why would humans have evolved a propensity to be either liberal or conservative when those labels did not exist until the end of the 18th century (Hibbing, Smith, and Alford 2014)? Moreover, how could attitudes on topical issues like abortion, immigration, or gun control have a biological basis when these concepts did not exist in their current form until recently?

In order for political attitudes and behaviors to have a solid theoretical foundation in biology, an explanation addressing the evolutionary recency of mass-scale politics is required. Fortunately, other evolutionarily recent but biologically based phenomena provide powerful examples. To illustrate, although reading is an extremely recent phenomenon on an evolutionary timescale, scientists have already identified key genetic predictors of reading performance (Alford and Hibbing 2008). Studies have demonstrated that a particular allele on chromosome 6 is implicated in the occurrence of a neurobiological reading disorder, dyslexia. How is this possible? Humans have the ability to translate foundational processes into more recent attitudes or behaviors. In this example, the cognitive processes involved in reading originally evolved for unrelated functions but were adapted to play a role in more contemporary behaviors.

The same evolutionary mechanism is likely at play in the development of political attitudes. While mass-scale politics is recent, it is based on underlying predispositions with an evolutionary role. In other words, contemporary political attitudes and behavior rely on antecedent genetic and neural processes that evolved to cope with more basic social decision-making: decisions about social organization, achieving group goals, or the distribution of resources (J. Fowler and Schreiber 2008). These relatively novel instruments for the formation of political attitudes coopted biological systems that evolved for other, more basic purposes (Alford and Hibbing 2008).

In particular, strength of ideological orientation and partisanship is likely to have served evolutionarily antecedent functions. For example, identification with a given ideology or party provides group membership, and group membership has been critical for security and survival throughout human history. This basic necessity for social identification has been adapted to the current political environment; an environment characterized by increasingly polarization, both ideological and affective. The novel context of polarization, whereby issue positions have become increasingly separate on the left/right spectrum, has interacted with the human primal need for social identification to create a scenario in which citizens have become more strongly attached to their own political groups, and less willing to cooperate with political outgroup. Thus, the very recent phenomenon of political polarization represents, in part, an evolutionary important need for group attachment.

Polarization and Attachment

Given the evolutionary role of group attachment, particularly in response to threat or uncertainty, it is critical to understand the current trend in political polarization and its consequences. Polarization has been apparent within Congress since the late 1970's, and data suggests an asymmetric movement in that the Republican party now accounts for the majority of the divergence between the parties (McCarty 2015). The degree to which voters have become more polarized in their views is still debated, but there is a general consensus that elite polarization has resulted in what has been termed "partisan sorting" (McCarty 2015). Partisan sorting describes the process by which voters change their issue positions to match their partisanship. As partisan sorting has progressed, the political parties have become more homogenous and the members of each have grown increasingly isolated from outside perspectives or opinions. That members of a political party would change their beliefs to match that of their group validates the importance and power of social identity.

The consequences of political polarization are apparent both within the political context and within the social environment more broadly. Perhaps most clearly, polarization has significantly decreased the functioning of government (McCarty 2015). Incentives for bipartisanship and cooperation have vanished, government has become less productive, and legislation and appointments are passed or approved more slowly than ever. Even on issues with profound societal impacts and broad-based public support, government officials seem to have reached an impasse and progress has halted. Almost without exception, government officials have prioritized partisan purity over achieving results and almost all issues have become politicized (Finkel et al. 2020).

Outside of politics, political polarization has potentially even stronger implications: Americans are growing more disdainful and distrustful of citizens of the other party. This animosity between rank-and-file members of the political parties is referred to as affective polarization, and it has been found to be a prevailing influence on social interactions, professional decisions, and economic behaviors (Iyengar et al. 2019). Partisanship makes a particularly powerful identity both because it is acquired early in life and because nearly constant political campaigns consistently amplify this group identity above all others (Iyengar et al. 2019). As a result of polarization, political group membership has gained supremacy over other social group memberships, which has altered the social structure entirely.

In fact, affective polarization has become so impactful that partisanship has begun to influence public health and dictate individual choices on health decisions. As evidenced by the response to the coronavirus pandemic, partisanship and ideological orientation are powerful predictors of vaccination rates, despite overwhelming scientific evidence demonstrating vaccine efficacy (Allcott et al. 2020). The degree to which citizens experience political polarization has also been shown to be linked to a decline in their physical health and wellbeing. For example, evidence suggests politically extreme individuals report worse health outcomes than individuals who feel closer to the political median in their state (Fraser et al. 2022).

Partisan and ideological identities are also leading to social polarization, whereby interpersonal interactions in social environments are dictated by feelings of group defensiveness (Mason 2015a). The subconscious need to defend one's own group means that as partisan and ideological attachments grow stronger and more aligned, prejudice against opposing groups is heightened. Moreover, when one social group conflicts with another, as is frequently the case in a politically polarized environment, group identity becomes more central to its members. The prominence of group identity under conditions of conflict fosters a malevolence toward the outgroup that is automatic and innate (Mason 2015a).

The concepts of affective and social polarization further support the significance of understanding social identity in a politically polarized nation. As political groups move farther apart, strength of group attachments will continue to increase in parallel. Research has consistently indicated that the combination of polarized groups and strong group attachments does not bode well for government function, social interactions, or democracy overall. Still, the consequences of political polarization may be reversible. Only through a comprehensive review of the biological bases of our political identities can the seemingly dire consequences of polarization be confronted.

Neurobiology and Genetics in Political Science

The incorporation of biological principals into the study of political attitudes and behavior has been termed "biopolitics," and it encapsulates both the study of neurobiological mechanisms - “neuropolitics” - and genetic mechanisms - “genopolitics.” It is not a replacement for traditional models of political behavior; rather, it is best utilized as a supplement that allows for an explanation of innate and deep-seated attitudinal and behavioral differences. The earliest studies of political attitudes and behavior to integrate biology yielded remarkable results that could have changed the theoretical groundwork, but were largely ignored. For example, Martin et al. (1986) showed that a meaningfully large proportion of the variation in individual political attitudes was attributable to genetics. Still, it was not until decades later that the genetic basis of political attitudes was acknowledged more broadly (Alford, Funk, and Hibbing 2005), and neurobiological studies began in earnest (Schreiber 2005).

Genopolitics

The 1986 study demonstrating that a substantial proportion of the variation in political attitudes was attributable to genetics was based on a survey of over 60,000 twins and their families (Martin et al. 1986). The Wilson-Patterson Inventory was included in this survey, which measures political and social attitudes. This study, and the majority of genopolitics studies in political science are based on the Classic Twin Design (CTD) approach. Generally speaking, identifying specific genes responsible for any social attitude or behavior is a challenging task, so geneticists and social scientists alike often turn to twin studies instead. Twin studies reveal the extent to which genes influence a particular trait rather than isolating the specific genetic alleles linked to that trait.

The power of twin studies relies on the fixed ratio of similarity between two types of twins: monozygotic (MZ) and dizygotic (DZ) twins (Alford, Funk, and Hibbing 2005). MZ twins come from a single egg fertilized by a single sperm, so they share 100% of genetic material. DZ twins, on the other hand, come from two separate eggs fertilized by two separate sperms, and thus share 50% of genetic material like any other siblings. If a characteristic is heritable, the tendency for MZ twins to share that trait will be stronger than the tendency for DZ twins to share it. If a characteristic has no genetic influence, there will not be any significant differences between MZ and DZ pairs.

The variation in any characteristic, including political attitudes and behaviors, is comprised of hereditary (H) and environmental (E) influences. On a population-level, heredity constitutes the overall effect of genetic inheritance on variation, while environment includes all non-genetic factors. From the womb to adulthood, every individual is exposed to variegated environmental influences that impact observable outcomes. Environmental influences are further divided into shared environment and unshared environment. The shared environment consists of all the external influences similar between pairs of twins. This includes environmental conditions like peer and parental socialization. The unshared environment represents all of the disparate external influences between individuals, which generally exert a stronger effect in adulthood than childhood.

Twin studies are not without limitations. A key assumption of CTD, the environmental equivalence assumption (EEA), is frequently questioned. Twin studies necessarily assume that environmental influences across MZ and DZ twin pairs is not significantly different. While there may be some variation in some environmental sources between some twin pairs, the assumption is that, on average, the variability is randomly distributed between MZ and DZ pairs. For example, challengers will contest that MZ twins are treated as more similar by parents, extended family, friends, or teachers than DZ twins. However, many pairs of MZ twins are also treated as less similar to help distinguish them from one another and encourage the development of individual identities.

In political science, twin studies have demonstrated that while political ideology is highly genetically influenced (Alford, Funk, and Hibbing 2005), party identification is not (P. K. Hatemi et al. 2009). Party identification is instead shaped primarily by parental socialization, in congruence with traditional models of partisanship. At the same time, the strength of party attachment is significantly influenced by genes (P. K. Hatemi et al. 2009). Political behaviors, like voting, have also been found to have a genetic basis. For example, Fowler, Baker, and Dawes (2008) showed that voter participation is both genetic and environmental. The variation in other politically relevant behaviors like cooperation, altruism, and attitudes towards risk has also been attributed in part to genetics (J. H. Fowler and Kam 2007).

Though much less common within political science, a handful of studies have moved away from twin studies in an attempt to identify specific genes that are associated with political attitudes or behaviors. Importantly, these initial studies are reinforced by a strong theoretical framework. Genes linked with neurotransmitters known to influence social behaviors, such as dopamine and serotonin, were analyzed first. Fowler and Dawes (2008) found that a gene integral to the regulation of serotonin (5HTT) was linked to voter turnout (as was a MAOA gene), and in another study, a dopamine receptor gene (DRD2) was a significant mediator of the relationship between voter turnout and proclivity towards party affiliation (Dawes and Fowler 2009). This approach is in a very nascent stage, and replication is necessary.

However, it would be a grave misunderstanding to equate a single gene with a single social attitude or behavior. Genes do not produce behavior; genes provide instructions for the creation of proteins that in turn govern the functioning of the brain, which then translates into behavioral outputs. Proteins are made from amino acids, which are combined in various ways to produce specific chemical structures. Proteins often serve as enzymes that interact with other chemicals in the body to facilitate chemical reactions. If a gene encoding a particular enzyme is missing or altered, the chemical reaction for which it is responsible will occur less efficiently, or in some cases, not at all (Alford, Funk, and Hibbing 2005).

Social traits are complex, multifactorial, and highly influenced by the surrounding environment. Very rarely does a single genetic allele induce a specific behavior, or even a specific disease. The most frequently cited example of a gene leading to a disease is Huntington's chorea. A mutated version of a single gene on chromosome 4 results in the emergence of this disease in midlife, and the absence of these gene entirely leads to a different disease: Wolf-Hirschhorn syndrome (Ridley 2000). Huntington's chorea represents genetic determinism; if an individual possesses this gene mutation, they will get the disease. The popular understanding of this disease has resulted in a wide-spread misunderstanding of the default operation of genes.

In the vast majority of circumstances, the impact of genes is not Mendelian. In other words, the influence of genes is almost never determinative; it is instead gradual and cumulative and highly dependent on environmental variability. Rather than envisioning a direct relationship where genes lead to political attitudes (or any trait), genes are best conceptualized as influencing people's sensitivity to particular environmental stimuli. Genes are more likely to impact the flexibility of attitudes than the actual attitudes themselves. For example, genes may influence the extent to which individuals are susceptible to depression or addiction, based on the environmental context (Alford and Hibbing 2008). This is particularly true for social characteristics, like political attitudes, which are produced by a limitless combination of genetic and environmental factors.

Neuropolitics

To link genetics to behavior, neuropolitics addresses the intermediary stages of neurobiology and physiology. Neurobiological and physiological indicators are more proximate measures of a biological basis for differences between political ideologies than genetic analyses, and these approaches have yielded significant results in support of evolutionary theories of political attitudes and behavior. For example, in the first study connecting individual differences in political attitudes to neurocognitive processes for self-regulation, Amodio et al. (2007) show that liberals demonstrate greater conflict-related neural activity in the anterior cingulate cortex (ACC) when response inhibition was required in a Go/No-Go task, as revealed by event related potentials. This suggests that the foundational difference between liberals and conservatives translates onto the self-regulatory mechanisms of conflict monitoring. Conservatives display less neurocognitive activity in response to conflict monitoring than liberals and would thus be best suited for tasks in which a fixed response is optimal (Amodio et al. 2007).

In a study examining physiological threat response, Oxley et al. (2008) find a significant difference between liberals and conservatives in skin conductance and orbicularis oculi startle blink. While the basic response pattern for a threat response is the same for everyone, individual variation in that response correlates strongly with political attitudes. One possible explanation for this relationship is that humans vary in general physiology, and these differences predispose one to adopt a particular set of political attitudes. That is, if one's automated response to threat or fear is above average, it may encourage the individual to hold more conservative political attitudes. On the other hand, it may be that holding a particular set of political attitudes alters one's physiology, such that the response to fear or threat is heightened.

These physiological studies of ideology have provided the basis for neuroimaging approaches. Imaging, both structural and functional, is the foundation of cognitive science and has been applied to political attitudes. At its most basic level, magnetic resonance imaging, or MRIs, are powerful magnetic devices that create magnetic fields. For structural imaging, the magnetic field yields distinct patterns of magnetic change around protons in water hydrogen in the body. These small changes in the polarization of protons allows different types of tissues within the body to be imaged. This allows neuroscientists to differentiate distinct parts of the brain. For functional imaging, a series of images is taken that permits the detection of changes in blood oxygen level dependent (BOLD) signals. BOLD signals vary with shifts in the oxygen in cerebral blood flow, since oxygenated blood has a different magnetic signature than deoxygenated blood. Beginning in the late 1990's, neuroscience research (e.g., the work of Paul Broca) began to demonstrate that specific brain functions appeared to occur in localized neuroanatomical structures. Since then, 1000s of fMRI studies have been conducted (Schreiber 2017).

Studies utilizing structural or functional imaging have produced remarkable findings. For example, Kanai et al. (2011) demonstrate that four brain regions are significantly different between liberals and conservatives: the right amygdala, the left insula, the right entorhinal cortex, and the ACC. These regions are implicated in processing risk and uncertainty, which lends support to the hypothesis that ideology is connected to deeper emotional and cognitive processes. However, this study is limited in that it was conducted on a demographically homogenous group of subjects.

Schreiber et al. (2013) expand on the aforementioned study by using voter records to explore functional brain differences between Democrats and Republicans during a risk-taking task. The results are remarkable: activation in amygdala and insula correctly predicts 82.9% of self-reported partisan identity (Schreiber et al. 2013). Democrats have significantly greater activity in the left insula, while Republicans have significantly greater activity in the right amygdala. Classic models of political socialization based on maternal and paternal partisanship only predict 69.5% of individual response, and structural differences predict 71.6% (Schreiber et al. 2013). It appears to be true that liberals and conservatives engage in distinct risk-taking cognitive processes, with conservatives showing more sensitivity toward threat.

Other neuroimaging studies have shown differential neural responses to political candidates (Kaplan, Freedman, and Iacoboni 2007; Knutson et al. 2006), differences in amygdala function towards threat (Pedersen, Tugan Muftuler, and Larson 2018), and differences in memory for negative stimuli (Mills et al. 2016a) between conservatives and liberals. Functional imaging has also provided support for other political information processing phenomena like motivated reasoning. Motivated reasoning is an implicit form of emotion regulation in which strong partisans seek to minimize negative affect states associated with a threat to their motives. Neural response of partisans to threatening information was associated with activations in areas not linked to "cold" or conscious reasoning, suggesting that motivated reasoning is qualitatively different than other forms of information processing (Westen et al. 2006). Biased processing has also been found in neural activity between liberals and conservatives with exposure to the same political stimulus (Leong et al. 2008). Clearly, neuroimaging approaches to political attitudes and behavior have the potential to greatly increase the scientific understanding of these social phenomenon, but more work is needed.

Overview of the Dissertation

The argument offered in this dissertation is that political attitudes and behaviors are innate and biologically driven. I offer an evolutionary biology perspective of human politics which revolves around the neurobiological and genetic foundations of political attitudes, particularly ideological and partisan extremism. The recent increase in political polarization and partisan sorting (Sides and Hopkins 2015) suggests that liberals and conservatives and Democrats and Republicans are becoming more distinct, and I argue that extremists on both sides of the political spectrum may share biological similarities when compared to political moderates or those who are apathetic to politics altogether. To address this hypothesis, I test whether extreme attitudes on either end of the political spectrum are structurally or functionally biologically distinct from more moderate citizens. I also explore neurobiological differences between liberals/Democrats and conservatives/Republicans in a yet untested emotional regulation paradigm.

Chapter 2 explores differences in structural neuroanatomy between political extremists and political moderates. Extant structural brain images studies have found significant differences between liberals and conservatives in the right amygdala, the left insula, the right entorhinal cortex, and the ACC (Ryota Kanai, Feilden, et al. 2011). Each region has been implicated in cognitive processes involved in evaluating risk, but of particular importance are the right amygdala and ACC. In previous studies, liberals displayed increased gray matter in volume in the ACC, and conservatives had greater volume in the right amygdala. The amygdala processes affective attributes of decision-making, and the ACC is responsible for conflict and error monitoring. To date, no studies have examined structural differences in the neuroanatomy of political extremists compared to political moderates.

Chapter 3 investigates functional neurobiological differences between political extremists and political moderates. Functional imaging studies have also found notable differences between liberals and conservatives or Democrats and Republicans. There is ample evidence that political ideology or party is related to selective attention processes, wherein conservatives display greater attention to- and activity towards- negative or threatening stimuli. For example, Carraro et al. (2011) use the Emotional Stroop Task to find that negative information impairs the performance of conservatives. That is, conservatives have an automatic, selective attention toward negative or threatening stimuli. Again, no studies have focused on differences in functional neuroanatomy between political extremists and moderates of either ideological orientation.

Based on the extremism hypothesis, it is possible that some of the same neurobiological differences found between liberals and conservatives will be reflected when comparing politically extreme and moderate citizens. Simply put, political extremes of either orientation will present neurobiologically consistent with political conservatives in areas relevant to processing uncertainty and threat. Specifically, strong attachment to ideology or party will be reflected in greater amygdala, insula, and entorhinal cortex volume and reduced anterior cingulate cortex volume when compared to political moderates in a structural analysis. During functional neuroimaging tasks, it is expected that strong attachment will lead to increased impairment when faced with negative stimuli when compared with political moderates.

In Chapter 4, a more traditional comparison in functional neuroanatomy between liberals/Democrats and conservatives/Republicans is examined. Functional tasks have been previously used to assess the classically known characteristics of liberals or Democrats and conservatives or Republicans, but none have focused explicitly on emotion regulation. Applying the Emotional Regulation Task to these groups may reinforce extant biopolitical findings, as well as generate novel knowledge regarding the functional neuroanatomy underlying political distinctions.

Research Design and Methods

In order to test these hypotheses, a sample of participants was derived from hospital admissions or injury-related visits to an urban, midwestern Level 1 Trauma Center. Potential participants were approached by study staff and asked if they would like to hear about a research study. If the patient responded in the affirmative, they were provided with study details and their first visit was scheduled. Demographic and injury characteristics for enrolled participants was obtained through medical chart abstraction and through data recorded in the Froedtert Hospital Trauma Program Trauma Registry.

The recruitment goal for this study was to enroll 100 patients who were risk-positive for the development of PTSD. This approach may be considered a sample of convenience. While this group of participants has been exposed to trauma and is, as a result, risk-positive for the development of PTSD, it is assumed that there is no relationship between trauma and political ideology. That is, the effects of trauma are anticipated to be distributed evenly among the sample, regardless of political ideology. If liberals or conservatives, or moderates or extremists, were differentially affected by exposure to potentially traumatic events, comparisons between the groups may not be accurate. Data will be analyzed to test for these differences empirically.

During the first visit, consent to participate was obtained. Participants completed a series of questionnaires and had blood drawn (5mL) for DNA extraction for the genome-wide DNA methylation analysis. Questionnaires included: PCL-5, ETV-C, PEDQ, psychiatric history, substance abuse, CTQ, CESD, DERS-SF, DSI-SS, SBQ-R, MTOP COVID-19 Inventory, MTOP Demographics Inventory, and the LEC. Differences in demographic or trauma-based characteristics will also be analyzed.

Table 1. Study Surveys

Survey Name	Measurement
Life Events Checklist	Measures exposure to potentially traumatic events in life
Exposure to Violence-Community	Measures how often people are exposed to threats in their communities
Childhood Trauma Questionnaire	Measures early traumatic experiences and assess understanding of childhood trauma

Perceived Ethnic Discrimination (Brief)	Measures perceived racism and ethnic discrimination
Suicide Behaviors Questionnaire	Measures suicide ideation and attempts
Posttraumatic Stress Disorder Checklist (PCL-5)	Measures presence and severity of PTSD symptoms
MTOP Demographics Inventory	Measures respondent demographics
MTOP COVID-19 Inventory	Measures respondent exposure to and stress regarding COVID-19
Injured Trauma Survivor Screen	Measures risk for development of PTSD
Difficulties in Emotion Regulation Scale (Short Form)	Measures issues in emotional regulation
Center for Epidemiological Studies Depression Scale	Measures symptoms associated with depression
Clinician Administered PTSD Scale (CAPS-5)	Measures diagnosis of PTSD and severity
Depressive Symptom Index-Suicidality Subscale	Measures suicidal ideation severity

Importantly, political affiliation and political ideology were also collected at visit one. Respondents were asked to identify as either a strong Republican, a weak Republican, neither a Republican nor a Democrat, a weak Democrat, or a weak Republican. Respondents were also asked to select their ideological orientation: strongly conservative, weakly conservative, neither conservative nor liberal, weakly liberal, or strongly liberal. This Likert-scale approach generates a more detailed characterization than a dichotomous liberal/conservative or Democrat/Republican variable. It also allows subjects to be classified as either strong partisans/ideologues or weak partisans/ideologues. Given the proliferation of partisan sorting, whereby partisanship and ideology are more closely correlated than ever before, these variables are anticipated to be correlated, but will be analyzed separately. Differences between the social identities of partisanship and ideological orientation will be analyzed explicitly.

Of the 100 participants who screened risk-positive for PTSD, approximately 50 participants further completed the neuroimaging protocol. The MRI study design includes two functional tasks, the Emotion Regulation Task and the Stroop Task, as well as a structural neuroanatomical scan. Differences in structural and functional neuroanatomy between political extremists and moderates will be assessed.

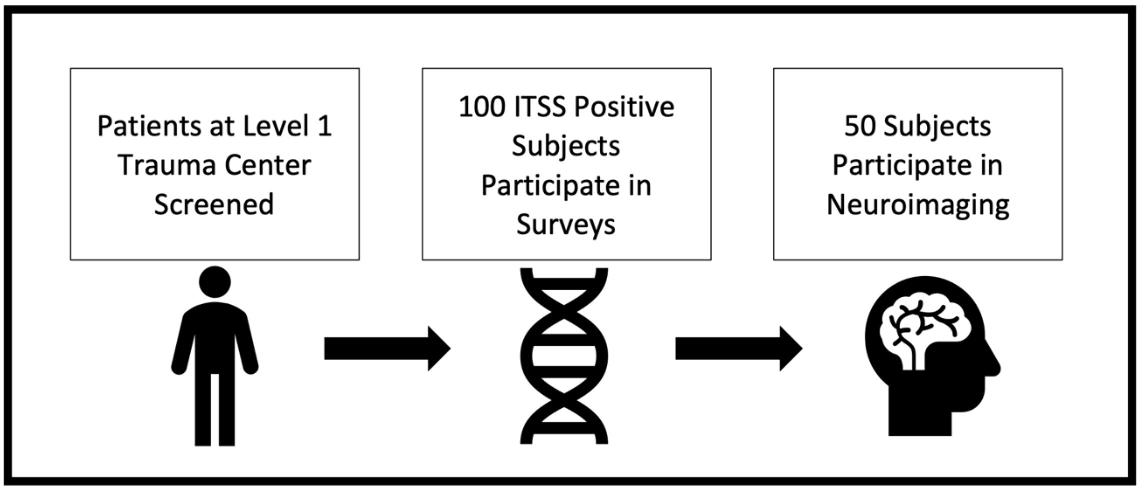

Figure 1. Sample Selection

Conclusions

This dissertation leverages methodologies within the fields of genetics and neuroscience in an attempt to advance the understanding of political attitudes and behaviors. While notable progress has made in evaluating the biological bases of liberalism and conservatism, very little attention has been paid to the geno- or neuro-political foundations of political extremism on either end of the ideological spectrum. The argument offered here is that strength of attachment to ideology or party as a group is the result of evolutionarily critical drives for safety and security, as well as the innate psychological motivation for social identification and the alleviation of uncertainty and fear. Given its evolutionary role, strength of group membership is expected to be reflected in biological comparisons between political extremists and political moderates.

The contributions of this proposed study are twofold. First, adding to the extant literature on biopolitics may lead to a tipping point, wherein the biological mechanisms underlying political identity will become fully incorporated and acknowledged within the political science community. Once a preponderance of evidence has been reached, political scientists will have no choice but to recognize the impact of biology on all human behavior and attitudes, not excepting those within the political realm. In this way, the entire field can move forward with novel research ideas or agendas and keep pace with other scientific areas which already accept the biological basis of human nature.

Secondly, this study has normative implications, particularly in an increasingly polarized political environment. As polarization becomes progressively affective in nature, it is critical to develop an empirical framework through which variation in political extremism can be studied. Current studies of polarization do not address the root causes of strong ideological or partisan attachment, and instead focus exclusively on external factors that heighten this innate biological response. Only by appreciating group attachment at its most fundamental level can appropriate tools be developed and implemented to foster cooperation over antagonism and productive debate over verbal and physical assaults. Through this framework, political communications could be applied more effectively to targeted populations and political ideologues could find a common language through which civil discussions could arise. Perhaps there could also be more compassion, tolerance, and acceptance of others if ideological or partisan identities were conceptualized in terms of genetic and neurobiological differences.

While a comprehensive understanding of the biological and evolutionarily origins of political attitudes and behaviors may help to provide solutions to profound contemporary social issues, it is important to clarify the limitations of such approaches. A biological framework for political group attachments does not suggest that one group is superior to the other, or that groups should be manipulated to achieve strategic objectives. Instead, the framework would simply help politicians and ordinary citizens alike understand the basis of their own attitudes and behaviors, as well as the attitudes and behaviors of their political counterparts. Furthermore, it is worth stating that political extremism is not inherently negative; still, there are certain circumstances where strength of group attachment could be reduced for a universal improvement in the political environment. Political extremists could choose to dampen the strength of their political attachments under specific conditions to favor progress if, and only if, they are able to able to recognize the fear and uncertainty driving their extremism.

The first step in achieving these goals is to encourage and expand the utilization of interdisciplinary methods within the field of political science. Geneticists, neuroscientists, and psychologists have already demonstrated the utility of these techniques in explaining human behavior, and political behavior is arguably one of the most powerful and impactful arenas for the study of behavior. Each study proving empirical support for the recognition and acceptance of biopolitical approaches is an important contribution to the field of political science, and the analyses herein are intended to do exactly that.

Chapter Two: The Evolutionary Basis of Political Attachment

Introduction

Conventional theories of political science attribute the transmission of political attitudes to social learning, particularly parental socialization (Campbell et al. 1960; Hyman 1959; Tedin 1974). According to this perspective, children learn by observing and modeling the political orientations manifest within their societal context, especially those of their parents. Political attitudes are conceptualized as the cumulative result of socialization, environmental factors, socioeconomic status, and political institutions. These theories are supported empirically by statistically significant correlations between the political attitudes of parents and their offspring (Jennings, Stoker, and Bowers 2009). Not only does this correlation exist in childhood, but the socialization process is theorized to extend its influence on the political attitudes of offspring well into adulthood.

However, more recent work in the interdisciplinary field of biopolitics has revealed that the correspondence in political attitudes between children and their parents may also be the indirect effect of biological inheritance. While the heritability of social attitudes was demonstrated as early as the mid-1980's (Martin et al. 1986), it was not until many years later that the biological underpinnings of political attitudes were more fully recognized. Genetic studies have confirmed that political attitudes, strength of party attachment, and political behaviors like voting are substantially shaped by genetics (Alford, Funk, and Hibbing 2005; J. H. Fowler, Baker, and Dawes 2008; P. K. Hatemi et al. 2009). Specific genes have also been identified for their roles in voter turnout and proclivity towards party affiliation (Dawes and Fowler 2009; J. H. Fowler and Dawes 2008), though further replication is necessary.

Physiological and neurobiological studies have similarly contributed to the academic understanding of the biological mechanisms that guide the development and maintenance of political attitudes. Studies employing physiological measures like event related potentials, skin conductance, and orbicularis oculi startle response have shown that conservatives display reduced neurocognitive activity in response to conflict monitoring than liberals (Amodio et al. 2007), but a higher physiological threat response (Oxley et al. 2008). Neuroimaging studies have also found that liberals and conservatives differ in amygdala and insula activation (Schreiber et al. 2013), neural reactivity to political candidates (Kaplan, Freedman, and Iacoboni 2007; Knutson et al. 2006), and amygdala function in threatening situations (Pedersen, Tugan Muftuler, and Larson 2018).

Findings from biopolitics studies provide strong empirical evidence for the incorporation of an evolutionary framework of political attitudes and behaviors into political science research, but the evolutionary theories offers ample support as well. Fundamentally, evolutionary explanations acknowledge that all human attitudes and behaviors, including those which are explicitly political, have evolved over time. Specifically, human biology has evolved functionally specialized mechanisms through adaptations to solve intrinsic, human problems (Tooby and Cosmides 1995), and there is no reason to believe that political attitudes or behavior are any different. In fact, many human behaviors with evolutionary importance, like cooperation, conflict, and identifying kin, have political motives and contemporary correlates (P. Hatemi and McDermott 2011). Where rational choice, institutionalist, or behavioralist theories fail to address the root causes of preferences, or why they differ between individuals, evolutionary theories seek to fill these gaps. Importantly, an evolutionary perspective does not negate the influence of socialization or other external factors; instead, it simply recognizes the importance of human biology in the development of theories of human behavior.

The dismissal of biological factors common to early theories of political attitudes is misguided, and further investigation into the biological structure underlying individual differences in political orientations is necessary. In order to understand from where political preferences originate, and why individuals differ in political orientations despite similarities in observable characteristics, a biological approach is required. While extant neurobiological studies have focused exclusively on differences between liberals and conservatives or Democrats and Republicans, no studies have examined differences between political moderates and political extremists; that is, the strength of attachment to ideological or partisan political groups. In an increasingly polarized political environment, extreme political attachment has become a normatively negative phenomenon benefiting from further elucidation. Given the known biological mechanisms associated with direction of political orientation, strength of political group attachment may also correlate with neurobiological and genetic foundations. Evaluating this relationship is worthy endeavor, as it may offer new insights into political extremism and targets for intervention. This study seeks to fill the lacunae by analyzing strength of political attachment with respect to structural neurobiology.

Political Group Attachments

Social identity theory explains why individuals belong to groups and what consequences may arise from group membership (H. Tajfel and Turner 1979; Henri Tajfel 1970). More specifically, it is a social psychological theory of how individuals perceive their place in social environments and how intergroup relations function. According to social identity theory, the self is reflexive: it can perceive itself as an object and categorize or classify itself in relation to other social groups. The process of self-categorization and social comparison forms an identity (Stets and Burke 2000). Moreover, an individual's social identity is perceptual; it is based on a person's knowledge of belonging to a group, together with the emotional and evaluative correlates of that group (Stets and Burke 2000). Group membership not only provides meaning in social contexts, but it also determines who the social self is and how it relates to others.

The group itself holds common views, and the defining characteristics of a given group provide guidelines for individuals in determining their own self-concept (Michael A Hogg, Terry, and White 1995; Stets and Burke 2000). As a result of social comparisons, social identity highlights perceived similarities between the self and the other members of the in-group, while simultaneously accentuating the perceived differences with out-groups. Due to the universal psychological motivation of maintaining a positive self-image, individuals are highly motivated to emphasize the positive traits and behavior of their ingroup and discount the negative characteristics (Michael A Hogg, Terry, and White 1995). Thus, the cognitive and psychological motivations to identify with social groups appear to be innate and engrained, which may extend to include identification with political groups.

While social identity theory does not explicitly reference the conditions under which group membership is strongest, it does conclude that intergroup behavior can become competitive when protection is necessary. The uncertainty-identity theory (M. A. Hogg, Meehan, and Farquharson 2010; Michael A Hogg and Adelman 2013) further conceptualizes the motivational processes of social identity and intergroup behaviors to stipulate that conditions of uncertainty yield a greater strength of group membership. Feelings of uncertainty are ubiquitously aversive; people have the desire to know who they are, what they should think, and how they should behave. Uncertainty-identity theory holds that uncertainty reduction is a particularly powerful psychological incentive, and social identification is one such method of reducing uncertainty. Group membership generates a sense of ingroup identification and belonging, which regulates feelings, behaviors, and interactions (Michael A Hogg and Adelman 2013). Therefore, basic psychological motivations like uncertainty reduction are theorized to influence one's strength of group attachment.

The psychological effects of uncertainty are situated within the political context explicitly through the extremism hypothesis (van Prooijen et al. 2015; van Prooijen and Krouwel 2017, 2019). The extremism hypothesis theorizes that political extremes at either end of the ideological or partisan spectrum are equally susceptible to the psychological motivation of reducing fear and uncertainty. According to this approach, political extremists, both liberal and conservative, have a higher propensity to display "rigidity of the right." Rigidity of the right is a term that characterizes conservativism as a form of motivated social cognition aimed at alleviating feelings of fear and uncertainty. That is, strong liberals and strong conservatives may share the same psychological motivation to combat fear and uncertainty despite other clear differences between the political orientations. The extremism hypothesis does not specifically reference partisan attachments, but the growing concordance between ideology and partisanship may be reflected with similar trends between strong Democrats and strong Republicans.

Importantly, the extremism hypothesis does not challenge or attempt to refute the well-established differences between liberals/Democrats and conservatives/Republicans. Liberals and conservatives and Democrats and Republicans have been consistently shown to differ on psychological and value-based measures (Caprara et al. 2006; Jeffrey J. Mondak 2010; Schwartz 2007), as well as subconscious physiological responses (Amodio et al. 2007; Pedersen, Tugan Muftuler, and Larson 2018; Smith et al. 2011; Vigil 2010). Conservatives are also known to report higher levels of fear and uncertainty on average than liberals, but this does not itself contradict the stipulations outlined in the extremism hypothesis. The relationship between uncertainty and political orientations is instead conceptualized as quadratic, whereby strong liberals and strong conservatives share the same response to fear and uncertainty through group attachment.

Extant research has provided ample support for the existence of shared cognitive mechanisms between extreme liberals and extreme conservatives. Political extremists at both ends of the political spectrum exhibit low cognitive complexity (*i.e.*, they think in terms of black or white and good or bad), and strong attachment to either party is also associated with increased perceptions of one's own correctness (Toner et al. 2013). Perhaps through the process of compensatory convictions, in which feelings of uncertainty or fear are correlated to increases in ideological certainty, both liberal and conservative political extremists are convinced of their own superiority (Mcgregor, Prentice, and Nash 2013). Furthermore, while liberals and conservatives frequently accuse their political counterparts of bias, a recent meta-analysis has found that partisan bias appears to be symmetric (Ditto et al. 2019). Mean levels of bias did not differ between liberals and conservatives, indicating another psychological feature shared by both ends of the spectrum.

Crucially, strong social identification has likely been used for the reduction of uncertainty or fear throughout human history, not just in contemporary politics. Group membership undoubtedly played a role in the maintenance of evolutionarily critical concepts like safety, security, cooperation, and coordination, and when faced with threat, belonging to a group naturally increases the odds of survival. While identification with a specific political ideology or party is an evolutionarily recent phenomenon, the human propensity for social attachment has been an innate and biological necessity since the earliest days. Simply put, the genetic and neurobiological correlates of political group identification have evolved from more basic group attachments required for human survival.

Traditional models of political group attachment ignore the evolutionary purpose of group membership. The focus of such research is on reactions to current political parties or leaders and the modern political environment, rather than the foundations of group affiliation itself. The evolutionary bases of preferences for political attachment have yet to be empirically examined, but it is reasonable to anticipate neurobiological correlates of the strength of social identification, including political ideology or partisanship. Indeed, biological foundations provide important insight into individual variation in preferences for many related concepts, including resource sharing, attitudes toward tolerance, and perceptions of fairness (P. Hatemi and McDermott 2011). Viewing the extremism hypothesis through an evolutionary lens, individual variation in group attachment may be due to psychological motivations aimed at reducing fear and uncertainty, and may therefore be reflected in neuroanatomy. Political extremists on either the left or right side of the political spectrum may be neurobiologically distinct when compared to political moderates, and structural neuroimaging is one method of ascertaining whether these differences are present.

Neurobiology and Behavior

Structural neuroimaging permits in-vivo brain morphometry to estimate gray matter volume, cortical thickness, and other related neuroanatomical measurements. The focus of structural neuroimaging is on brain structure, rather than function, and it is generally used to analyze and compare the size and composition of regions of the brain across individuals. Structural MRIs produce accurate high-resolution spatial representations of the density and volume of important neuroanatomical structures, which are assumed to play a role in inter-individual differences in human behavior and cognition (Ryota Kanai and Rees 2011). While the correspondence between brain structure and function has not yet been completely defined, empirical literature provides robust evidence that neuroanatomy is related to phenotypes of interest.

Structural brain-behavior correlations suggest that neuroanatomical differences are associated with individual variation in psychological or behavioral traits, ranging from cognition to affect to personality. For example, inter-individual differences in motor behavior, decision-making, perception, attention, and intelligence can be predicted by the structure of gray and white matter (Ryota Kanai and Rees 2011). One study demonstrated that distractibility in daily life is reflected in the structure of the parietal cortex, and when this region's function is disrupted through transcranial magnetic stimulation, subjects were more susceptible to distraction (Ryota Kanai, Dong, et al. 2011). In another study, moral values were found to be associated with individual differences in brain volume, with individualizing values being positively correlated with the left dorsomedial prefrontal cortex and negatively correlated with the bilateral precuneus, while binding was positively correlated with the bilateral subcallosal gyrus (Lewis et al. 2012). Other psychological constructs, like empathy, have also been found to be highly correlated with brain structures, including the precuneus, inferior frontal gyrus, and anterior cingulate (Banissy et al. 2012).

However, it is important to note that correlation is not causation, and the directionality of the relationship between neuroanatomical structure and cognition or behavior has not been elucidated. To illustrate, a study investigating the variation in participation in online social networks found neurobiological correlates of social network size. Specifically, the number of friends an individual declares on a social networking site reliably predicts gray matter density in the right superior temporal sulcus, the left middle temporal gyrus, and the entorhinal cortex (R. Kanai et al. 2012). Importantly, these brain regions have been implicated in cognitive processes related to social networking, like social perception and associative memory. What remains unclear is whether social networking influenced the structure of these regions, or if the structure of these regions influenced the degree to which the individual participated in social networks.

The source of variation in neuroanatomical structures is also debatable; structural variation in the brain could be the result of genetic or other biological mechanisms, environmental experiences, or the combination of both. Research has shown that one's environmental contexts can be a powerful influence on brain structure, as the brain is plastic and changes over time. For example, Maguire et al (2000) famously discovered that London taxi drivers displayed significantly larger posterior hippocampi than control subjects. The hippocampus was examined specifically because of its well-established role in spatial memory. Hippocampal volume was further correlated with the length of time the individual spent as a taxi driver (Griesbauer et al. 2022; Maguire et al. 2000). Other studies have found changes in gray matter after individuals had undergone training in juggling (Draganski et al. 2004), and changes in amygdala structure after stress-reduction interventions (Hölzel et al. 2009), to name a few.

Political Brains

Despite the importance of neuroanatomical structure on human cognition and behavior, very few studies have employed structural MRIs with respect to individual differences in the political realm. One structural study of political ideology found that liberalism was correlated with increased gray matter volume in the anterior cingulate cortex (ACC), while conservatism was associated with increased gray matter volume in the right amygdala (Ryota Kanai, Feilden, et al. 2011). The ACC was hypothesized to positively correlate with liberal ideology due to its role in processing uncertainty and tolerance. Individuals with a larger ACC may have a higher capacity for accepting conditions of uncertainty, and the ability to tolerate uncertainty is more prevalent among liberals than conservatives. Similarly, the amygdala was expected to positively correlate with conservative ideology because it is associated with managing fear. Greater amygdala volume may indicate that those individuals are more sensitive to fear, which is generally associated with conservatism.

Aside from these specific regions of interest, whole brain analyses revealed that gray matter volume was also significantly correlated with conservatism in the left insula and right entorhinal cortex. The left insula is known for its role in processing disgust, an evolutionarily important function to protect from physical harm. The entorhinal cortex is less clearly associated with known characteristics of conservatism, but it has been implicated in memory formation, and conservatives are known to have greater capacities for negative memories. Importantly, the structural findings for the ACC, the right amygdala, the left insula, and the entorhinal cortex were all replicated in an independent sample. Furthermore, using the ACC and right amygdala gray matter volumes to train a multivariable classifier, these structures were able to accurately predict liberalism and conservatism at almost 72% (Ryota Kanai, Feilden, et al. 2011). Combined with the theoretical basis for structural brain-behavior correlations, these empirical results strongly support a link between political ideology and neuroanatomy.

Other studies have also examined political ideology from a structural brain perspective. For example, Nam et al. (2018) found that larger bilateral amygdala volume was correlated with beliefs on preserving the existing social order. This tendency to defend the existing social system is known as system justification, and it is associated with conservative ideology. Thus, the structural findings are consistent across studies. Functional and physiological studies further confirm these results, demonstrating that liberalism is associated with stronger conflict-related ACC activity (Amodio et al. 2007), and that brain activity differs between Democrats (liberals) and Republicans (conservatives) in the left insula and right amygdala (Schreiber et al. 2013).

Studies of abnormal or damaged brains also reflect the importance of neuroanatomy on political attitudes and behavior. In a study of individuals with profound amnesia due to damage to the hippocampus, subjects consistently voted for candidates closest to their preferred issue positions (Coronel et al. 2012). These results suggest that accurate voting decisions do not necessitate recall or recognition of candidates and their positions. In another study of individuals with orbitofrontal cortex (OFC) lesions, damage did not affect the ability to make competence or attractiveness judgments of political candidates, but it did hinder the ability to use competence in making voting choices (Xia et al. 2015). In patients with damaged OFCs, only attractiveness was predictive of vote choice, while control patients used both competence and attractiveness.

While the importance of structural neuroanatomy on political ideology is beginning to be recognized, empirical research has focused solely on differences between liberals and conservatives. Considering the evolutionarily role of strength of attachment, it is reasonable to expect that structural brain differences will also be apparent when comparing political extremists to political moderates. Through this novel approach, the biological bases of polarization and out-group hostilities could be further elucidated. Specifically, combining the extremism hypothesis with findings of prior structural research examining the neuroanatomical differences between liberals and conservatives, a hypothesis can be formed. Since the extremism hypothesis developed by van Prooijen et al. (2015) finds that political extremists may mirror some of the same psychological motivations as traditional conservatives, and the volume of the amygdala, insula, and entorhinal cortex has been found to be larger among conservatives (Ryota Kanai, Feilden, et al. 2011), political extremists may also display greater volume in these critical brain regions. Kanai et al. (2011) also found that the ACC is smaller among conservatives due to its role in the tolerance of uncertainty, which may be similarly reflected in extremists.

While the extremism hypothesis does not differentiate between ideological and partisan political attachments, it is possible that these distinct social identities may not exert equivalent influences on neurobiological structures. Extant literature demonstrates that while strength of partisan attachment is genetically based, direction of partisan attachment is not (P. K. Hatemi et al. 2009). These results support the expectation that strength of political group attachment is correlated with biological variation, while indicating that whether one identifies with the Democratic or Republican party is indeed largely the result of socialization. Yet, ideological orientation itself has consistently been shown to have a significant genetic basis (Funk et al. 2013).

Studies conceptualizing partisanship as a social identity also distinguish between party attachments and ideological ones. From this perspective, a strong partisan identity is distinct from support for a particular ideological orientation; partisanship as an identity is determined by the degree to which one perceives of themselves as a member of political group, and it is not reliant on a given party's issue positions (Huddy and Mason 2010). To illustrate, empirical evidence has demonstrated that despite most Americans' centrist views on policy issues, Democrats and Republicans vote for their party's candidate in presidential elections at rates of over 90% (Erickson and Tedin 2007). Shared beliefs, according to this theory of partisanship, provide only one weak form of political identity, while partisan identity has a much stronger basis in similar lifestyles, personality traits, and even non-political values (Huddy and Mason 2010).

On the other hand, it is also worth considering the growing concordance between ideology and partisan affiliation, referred to as partisan sorting. As polarization has increased over the last four decades, voters have become better sorted within the major political parties (McCarty 2015). That is, voters with conservative ideologies are more likely to vote for the Republican party and voters with liberal ideologies are more likely to vote for the Democratic party than in previous decades. Furthermore, research suggests that issue positions are changing to match partisanship, and not the other way around—likely the product of elite polarization (McCarty 2015). Based on these trends, ideology and partisanship may be so intertwined that the brains of strong Republicans (Democrats) will mirror those of strong conservatives (liberals), or that whenever a strong Republican (Democrat) is present, they will also be a strong conservative (liberal).

Considering these potentially contradictory findings, it is important to test whether extreme ideologues have different neurobiological structures when compared to moderate ideologues, *and* whether extreme partisans have different neurobiological structures when compared to moderate partisans. If neuroanatomical differences are noted between strong ideologues but not partisans, or vice versa, this information can help define and characterize the concepts of political ideology and partisanship. Distinctions between attachments to the two groups may indicate that ideology and party arose from distinct evolutionary groupings, or that the basic human need to belong to groups evolved into separate forms. Ultimately, the expectation is that strength of attachment to either political grouping will present neurobiologically.

H1: Strong liberals/Democrats and strong conservatives/Republicans will have greater gray matter volume in the amygdala when compared to political moderates.

H2: Strong liberals/Democrats and strong conservatives/Republicans will have less gray matter volume in the ACC when compared to political moderates.

H3: Strong liberals/Democrats and strong conservatives/Republicans will have greater gray matter volume in the left insula when compared to political moderates.

H4: Strong liberals/Democrats and strong conservatives/Republicans will have greater gray matter volume in the right entorhinal cortex when compared to political moderates.

Methods

Sample

Participants were recruited from hospital admissions or visits to an urban, midwestern Level 1 Trauma Center. Subjects were approached for participation either in-person or via phone after discharge. Patients who agreed to participate were given the Injured Trauma Survivor Screen (ITSS) to measure risk for developing post-traumatic stress disorder and depression (Hunt et al. 2021). One hundred risk positive patients were included in the first portion of the study. Fifty of these subjects further completed the neuroimaging protocol: twenty-five with high scores on the PTSD diagnostic tool the PCL-5 (PCL-5>30), and twenty-five with low scores on the PCL-5 (PCL-5<10). Demographic and injury characteristics for enrolled participants was collected through medical charts and data from the Froedtert Hospital Trauma Program Trauma Registry. A separate visit was scheduled for the neuroimaging portion of the study.

Procedure

MRI scans were conducted two to four weeks after the date of trauma and subjects were compensated with $100 for their participation. After reviewing the MRI safety questionnaire, subjects entered the scanner with respiratory bellows and a pulse oximeter to gather physiological data. Participants were also given a button box for the functional tasks and a squeeze ball for comfort. Earphones were utilized to communicate with study staff.

Subjects participated in a resting state scan and two functional tasks before structural images were collected. Participants were instructed to lie still while the MRI scan was conducted. While these scans are not intended for diagnostic purposes, should a scan reveal an incidental abnormal finding, participants are referred to an appropriate consultant for a diagnostic exam.

Survey Measures

Political Affiliation

Data on political ideology and partisanship was collected at visit one. Respondents were asked to identify as strongly conservative/Republican, weakly conservative/Republican, neither conservative/Republican nor liberal/Democrat, weakly liberal/Democrat, or strongly liberal/Democrat. This Likert-scale approach generates a more detailed characterization than a dichotomous liberal/conservative variable, and accurately predicts voting behaviors (Ryota Kanai, Feilden, et al. 2011). Political extremists are classified as those identifying as either strongly conservative/Republican or strongly liberal/Democrat. Weakly conservative/Republican, weakly liberal/Democrat, and neither conservative/Republican nor liberal/Democrat subjects were classified as political moderates. Ideological and partisan scores were also created as continuous variables, with respondents who identified as neither receiving a score of 1, respondents who identified as weak receiving a score of 2, and respondents identifying as strong receiving a score of 3.

Demographics

Basic demographic characteristics were ascertained from participants including age, sex, race, and ethnicity. Sex was classified by what sex respondents were assigned at birth. Race was based on National Institutes of Health categories: American Indian/Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, Black or African American, White, Race not listed above, or prefer not to say. When two or more races were selected, the racial category was coded as two or more. Respondents were also asked if they consider themselves to be Hispanic or Latino, with an option to not provide the information.

Injury Characteristics

Injury characteristics included Mechanism of Injury (MOI) and Injury Severity Score (ISS). Mechanism of injury was originally recorded as either a motor vehicle crash, a gunshot, a stab, a fall, pedestrian struck, a motorcycle crash, a crush injury, domestic violence, assault/altercation, or other. This variable was recoded to combine motor vehicle crash with motorcycle crash and pedestrian struck. Domestic violence was also combined with assault/altercation. An Injury Severity Score describes the severity of a trauma patient's injury, and it is based on an established system of scoring anatomical injuries. Each of 6 body systems is first scored on an Abbreviated Injury Scale, with the 3 body systems with the greatest AIS scores utilized to calculate the ISS (the scores are squared and then summed). ISS ranges from 3-75.

Injured Trauma Survivor Screen (ITSS)

This 9-item checklist measures risk for the development of posttraumatic stress disorder and depression one month post traumatic injury. Items 3, 4, 7, 8, and 9 evaluate risk for posttraumatic stress disorder, while items 1, 2, 3, 5, and 6 evaluate risk for depression. A "yes" response to any question is scored as a 1, while "no" responses are scored as a 0. If the sum of either set of questions is greater than or equal to 2, the screen is positive for the risk of developing either posttraumatic stress disorder or depression. The screen was normed on a population of injured trauma survivors at a level 1 trauma center. It has not been validated on individuals with moderate to severe trauma brain injuries.

PTSD Checklist for DSM-5 (PCL-5)

This is a 20-item self-report survey that is utilized for monitoring posttraumatic stress disorder symptom change, screening for posttraumatic stress disorder, and making a provisional diagnosis of posttraumatic stress disorder. Each item asks the respondent how a symptom has bothered them since the traumatic injury on a scale of 1-5, with 1 being equivalent to “not at all,” and 5 being equivalent to “extremely.” The PCL-5 can be interpreted as a total symptom severity score (ranging from 0-80) or as scores for each symptom cluster in the DSM-5.

Clinician-Administered PTSD Scale for DSM-5 (CAPS -5)

This clinician-administered tool is the gold standard for the assessment of posttraumatic stress disorder. It is a structured interview consisting of 30 items that evaluate the 20 symptoms of posttraumatic stress disorder, as well as the onset and duration of symptoms, subjective distress and the impact of symptoms, change in symptoms, and overall severity. CAPS-5 is used to make current and lifetime diagnoses of posttraumatic stress disorder, and relies on symptoms cluster scores. The full interview takes approximately 45-60 minutes to complete by a trained clinician or clinical researcher.

Data Acquisition and Processing

Structural scans were conducted on a GE Signa Premier 3T scanner with high-speed gradients and a 48-channel head coil. Anatomical T1-weighted images were acquired in sagittal slices. Anatomical scans were processed cross-sectionally in Freesurfer (v.7.2.0) using the *recon-all* command for automated tissue segmentation and parcellation (https://surfer.nmr.mgh.harvard.edu). Results were inspected visually for quality assurance, but no manual adjustments were made.

Analysis

Bivariate analyses were conducted to examine differences in demographic and injury-related characteristics by strength of political ideology and party affiliation. Continuous variables were non-parametric and analyzed with Wilcoxon rank sum tests, while categorical variables were analyzed with Fisher's exact tests due to small cell sizes.

General linear models were applied to the structural data to determine whether gray matter volumes were associated with strength of partisan and ideological attachment after adjustment for total brain volume. All statistical analyses were conducted in R Statistical Software (v1.2.5042; R Core Team 2021).

Results

In total, 34 subjects had usable structural imaging data. When asked how they would describe their political attitudes, the majority of subjects responded with neither conservative nor liberal (n=18). The remaining subjects indicated that they are somewhat conservative (n=4), somewhat liberal (n=4), very conservative (n=1), or very liberal (n=7). Using these responses, a dichotomous variable was created to measure strength of political ideology, with 0 representing weak or no political ideology (n=26), and 1 representing strong ideology (n=8). Similarly, subjects were asked to describe their political party affiliation. Again, the majority of respondents were affiliated with neither the Democratic nor Republican parties (n=24). Subjects also identified themselves as a weak Republican (n=2), a weak Democrat (n=2), a strong Republican (n=1), or a strong Democrat (n=5). The same scoring method was calculated to determine weak or no political party affiliation (n=24) and strong political party affiliation (n=6). The small sample size and imbalanced nature of the groups is a limitation of this study.

Table 2 displays the demographic and injury characteristics of the sample. Median age was 28.5 (24.25-38.5), the sample was split equally by sex at birth (female=50%), and the majority of the sample was either black/African American (62%) or white (24%). The most common mechanism of injury among the sample was motor vehicle crash, pedestrian struck, or motorcycle crash (76%). Other mechanism of injury included domestic violence or assault (8.8%), fall (5.9%), stabbing (2.9%), or other (5.9%). Unfortunately, ISS was missing in 88% of respondents.

Table 2. Sample Characteristics

Characteristic	**N = 34**[1]
Age	28.50 (24.25, 38.50)
Sex	
Female	17 (50%)
Male	17 (50%)
Race	
2+	4 (12%)
AI or Alaskan	1 (2.9%)
Black	21 (62%)
White	8 (24%)
Hispanic/Latino	
Hispanic/Latino	2 (6.7%)

Characteristic	N = 34[1]
Not Hispanic/Latino	28 (93%)
Unknown	4
Injury Severity Score	8.00 (5.00, 11.50)
Unknown	30
Mechanism of Injury	
DV/Assault	3 (8.8%)
Fall	2 (5.9%)
MVC/Struck/Motorcycle	26 (76%)
Other	2 (5.9%)
Stab	1 (2.9%)
ITSS Total	7.00 (5.00, 8.00)
PCL-5 Total Score	51.00 (39.50, 59.75)
CAPS-5 Total Score	16.00 (8.00, 23.00)
Unknown	7
CAPS-5 PTSD Diagnosis	10 (37%)
Unknown	7
Strength of Ideology	
Strong	8 (24%)
Weak	26 (76%)
Strength of Partisanship	
Strong	6 (18%)
Weak	28 (82%)

[1] Median (IQR); n (%)

Differences between strong and weak political ideologues are presented in Table 3. There were no statistically significant differences between the groups in terms of demographic, injury, or trauma-related variables. Importantly, the groups were comparable on their ITSS total scores, their baseline PCL-5 scores, and their CAPS-5 diagnoses at 6 months after trauma. This suggests that the effect of trauma on this sample did not vary by strength of political ideology. While this sample should not be combined with non-trauma exposed populations, and the effect of trauma on neural imaging cannot be discounted, the lack of differences in tools aimed at measuring the effect of trauma between groups indicates that a comparison of structural scans is likely to reflect true distinctions.

Table 3. Strong and Weak Political Ideology

Characteristic	**Strong**, N = 8[1]	**Weak**, N = 26[1]	**p-value**[2]
Age	29 (25, 42)	28 (24, 37)	0.839
Sex			1.000
Female	4 (50%)	13 (50%)	
Male	4 (50%)	13 (50%)	
Race			1.000
2+	1 (12%)	3 (12%)	
AI or Alaskan	0 (0%)	1 (3.8%)	
Black	5 (62%)	16 (62%)	
White	2 (25%)	6 (23%)	
Hispanic/Latino			0.418
Hispanic/Latino	1 (14%)	1 (4.3%)	

Characteristic	**Strong**, N = 8[1]	**Weak**, N = 26[1]	**p-value**[2]
Not Hispanic/Latino	6 (86%)	22 (96%)	
Unknown	1	3	
Injury Severity Score	5.00 (5.00, 5.00)	11.00 (8.00, 12.00)	0.637
Unknown	7	23	
Mechanism of Injury			0.653
DV/Assault	0 (0%)	3 (12%)	
Fall	0 (0%)	2 (7.7%)	
MVC/Struck/Motorcycle	7 (88%)	19 (73%)	
Other	1 (12%)	1 (3.8%)	
Stab	0 (0%)	1 (3.8%)	
ITSS Total	6.00 (3.00, 8.00)	7.00 (5.25, 8.00)	0.390
PCL-5 Total Score	56 (47, 64)	50 (39, 58)	0.382
CAPS-5 Total Score	14 (8, 23)	17 (9, 23)	0.868
Unknown	1	6	
CAPS-5 PTSD Diagnosis	3 (43%)	7 (35%)	1.000
Unknown	1	6	

[1] Median (IQR); n (%)

[2] Wilcoxon rank sum test; Fisher's exact test

Table 4 similarly shows the relationships between demographic and injury indicators and strength of party affiliation. Strong and weak partisans do not significantly differ in terms of age, sex, race, ethnicity, injury severity, or mechanism of injury. While strong partisans had a statistically higher median PCL-5 score at baseline than weak partisans (64 (59-64) vs 50 (38-58), p=0.047), the groups did not differ in the gold standard posttraumatic stress disorder diagnostic tool, the CAPS-5 (p=1.000). The small sample size in the strong partisanship group has likely contributed to this statistical finding, but caution should still be employed when evaluated structural differences between the groups.

Table 4. Strong and Weak Political Partisanship

Characteristic	**Strong**, N = 6[1]	**Weak**, N = 28[1]	**p-value**[2]
Age	30 (24, 40)	28 (26, 38)	0.982
Sex			0.656
Female	4 (67%)	13 (46%)	
Male	2 (33%)	15 (54%)	
Race			0.733
2+	0 (0%)	4 (14%)	
AI or Alaskan	0 (0%)	1 (3.6%)	
Black	5 (83%)	16 (57%)	
White	1 (17%)	7 (25%)	
Hispanic/Latino			0.310
Hispanic/Latino	1 (20%)	1 (4.0%)	
Not Hispanic/Latino	4 (80%)	24 (96%)	
Unknown	1	3	
Injury Severity Score	5.00 (5.00, 5.00)	11.00 (8.00, 12.00)	0.637
Unknown	5	25	
Mechanism of Injury			0.682
DV/Assault	0 (0%)	3 (11%)	
Fall	0 (0%)	2 (7.1%)	

Characteristic	**Strong**, N = 6[1]	**Weak**, N = 28[1]	**p-value**[2]
MVC/Struck/Motorcycle	5 (83%)	21 (75%)	
Other	1 (17%)	1 (3.6%)	
Stab	0 (0%)	1 (3.6%)	
ITSS Total	7.50 (5.50, 8.75)	7.00 (5.00, 8.00)	0.584
PCL-5 Total Score	64 (59, 64)	50 (38, 58)	0.047
CAPS-5 Total Score	22 (8, 38)	16 (8, 22)	0.452
Unknown	2	5	
CAPS-5 PTSD Diagnosis	1 (25%)	9 (39%)	1.000
Unknown	2	5	

[1] Median (IQR); n (%)

[2] Wilcoxon rank sum test; Fisher's exact test

To test the hypotheses that political extremism is associated with differences in gray matter volume in the amygdala, ACC, insula, and entorhinal cortex when compared with political moderates, political ideology and partisanship were tested separately. Models were run with brain regions bilaterally, adjusting for total brain volume. Total brain volume was calculated as the sum of total cerebral white matter and total gray matter. Strong political identifiers were coded as 1, while weak political identifiers were coded as 0.

Table 5 reports the results from all four structural brain imaging volume models for political ideology. Results indicate that there were no statistically significant differences between political extremes and political moderates with respect to the bilateral amygdala, ACC, or entorhinal cortex. However, while the right insula shows no relationship to strength of ideological attachment, the left insula is negatively and significantly associated with strength of political attachment (ß=-0.003, p=0.038). That is, as left insula volume increases, strength of political attachment decreases. This finding is not robust to adjustments for multiple comparisons, or when models are run with covariates age and sex in place of total brain volume.

Table 5. Logistic Regressions of Strength of Political Ideology

Characteristic	log(OR)[1]	95% CI[1]	p-value
Left ACC	-0.000	0.00, 0.00	0.121
Right ACC	0.000	0.00, 0.00	0.480
Total Brain Volume	0.000	0.00, 0.00	0.582
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Amygdala	0.000	-0.01, 0.01	0.948
Right Amygdala	0.000	-0.01, 0.01	0.981
Total Brain Volume	-0.000	0.00, 0.00	0.938
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Entorhinal	-0.001	0.00, 0.00	0.428
Right Entorhinal	0.001	0.00, 0.00	0.459
Total Brain Volume	0.000	0.00, 0.00	0.907
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Insula	-0.003	-0.01, 0.00	0.038
Right Insula	0.000	0.00, 0.00	0.612
Total Brain Volume	0.000	0.00, 0.00	0.062

[1] OR = Odds Ratio, CI = Confidence Interval

This finding contradicts the hypothesis that greater strength of attachment will be associated with greater volume in the left insula, as derived from studies showing greater volume in the left insula among conservatives. Conceptually, because the left insula is known for its role in processing disgust, and disgust is positively associated with conservatism, a link between left insula volume and conservatism is expected (Ryota Kanai, Feilden, et al. 2011; Smith et al. 2011). Taken one step further, citizens with strong political attachment were anticipated to present with volumetric enhancements compared to political moderates given their shared "rigidity of the right" characteristics and the role of disgust in protection against threats evolutionarily.

It is important to note that 7 of the 8 subjects who were classified with strong ideological attachments reported being strong liberals. It is therefore possible that the results for the left insula are being driven by liberalism, rather than strong ideological attachments in either direction. While a larger, more balanced sample is necessary to alleviate remaining questions regarding the relationship between neuroanatomical volume of the left insula and strength of political ideological affiliation, as a sensitivity analysis, ideology was also operationalized as a score. For the scoring variable, 1 indicated neither ideological affiliation, 2 indicated a weak ideological affiliation, and 3 indicated a strong ideological affiliation. In this way, all subjects can be analyzed together, and additional right-leaning subjects can contribute to the trend of the continuous variable. As a score, 18 (53%) of respondents identified as neither ideology, 8 (24%) identified as weakly ideological, and 8 (24%) identified as strongly ideological. The weakly ideological group was split equally between weakly liberal and weakly conservative respondents. Results of this secondary analysis are displayed in Table 6.

Table 6. Linear Regressions of Strength of Political Ideology

Characteristic	log(OR)[1]	95% CI[1]	p-value
Left ACC	-0.000	0.00, 0.00	0.213
Right ACC	0.000	0.00, 0.00	0.863
Total Brain Volume	0.000	0.00, 0.00	0.466
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Amygdala	0.000	-0.01, 0.01	0.850
Right Amygdala	0.000	-0.01, 0.01	0.837
Total Brain Volume	-0.000	0.00, 0.00	0.907
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Entorhinal	-0.000	0.00, 0.00	0.397
Right Entorhinal	0.000	0.00, 0.00	0.449
Total Brain Volume	0.000	0.00, 0.00	0.702
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Insula	-0.001	-0.01, 0.00	0.024
Right Insula	0.000	0.00, 0.00	0.319
Total Brain Volume	0.000	0.00, 0.00	0.117

[1] OR = Odds Ratio, CI = Confidence Interval

As with the binary strong vs weak categorization of ideological attachment, treating strength of ideology as a continuous score revealed a negative, but statistically significant relationship between left insula volume and strong attachment (ß=-0.001, p=0.024). This consistent finding between operationalizations of strength of ideology provides additional evidence in favor of a true association, although the influence of strong liberal identifiers cannot be conclusively ruled out as the origin of the volumetric differences without a larger, more balanced sample. Nonetheless, replicating the prior results with a secondary analysis is meaningful, and further emphasizes the need for additional research in this area.

Model results for strength of political partisanship are displayed in Table 7. Unlike political ideology, strength of political partisanship shows no associations with any of the neuroanatomical regions. Differences between partisan and ideological groups were not hypothesized, but it does appear as though strength of partisanship is not related to left insula volume as with strength of ideology. The distribution of partisanship did shift slightly from ideology, with only 6 subjects self-reporting as strong partisans, while 8 subjects self-reported as strong ideologues. Strength of partisanship was also operationalized and tested as a score, with 24 (71%) respondents receiving a 1, 4 (12%) respondents receiving a 2, and 6 (18%) respondents receiving a 3. As with ideology, the weakly partisan group was equally split between Democrats and Republicans. Results of the linear regression are not reported here, but the null findings were replicated.

Table 7. Logistic Regressions of Strength of Political Partisanship

Characteristic	log(OR)[1]	95% CI[1]	p-value
Left ACC	0.000	0.00, 0.00	0.499
Right ACC	-0.000	0.00, 0.00	0.626
Total Brain Volume	-0.000	0.00, 0.00	0.306
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Amygdala	0.007	0.00, 0.02	0.144
Right Amygdala	0.002	-0.01, 0.01	0.504
Total Brain Volume	-0.000	0.00, 0.00	0.070

Characteristic	log(OR)[1]	95% CI[1]	p-value
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Entorhinal	-0.000	0.00, 0.00	0.742
Right Entorhinal	0.002	0.00, 0.01	0.270
Total Brain Volume	-0.000	0.00, 0.00	0.298
Characteristic	**log(OR)[1]**	**95% CI[1]**	**p-value**
Left Insula	-0.000	0.00, 0.00	0.604
Right Insula	-0.000	0.00, 0.00	0.834
Total Brain Volume	-0.000	0.00, 0.00	0.981

[1] OR = Odds Ratio, CI = Confidence Interval

Discussion and Conclusions

The findings from this study build upon previous structural neuroimaging work investigating the correlation between brain structure volume and ideology or partisanship. This is the first known work to explicitly examine differences in brain structure related to strength of political affiliation, rather than direction. Results indicate that political extremes have less gray matter volume in the left insula compared to political moderates, which runs contrary to the theoretical and hypothesized expectations for the insula. Several explanations may be offered for this unanticipated discovery.

First, the insula is an anatomically and functionally multifaceted region. Figure 2 depicts the location and subregions of the insula. Anatomically, the insula is a bilateral region located within the lateral sulcus separating the parietal and frontal lobes (Namkung, Kim, and Sawa 2017). It that can be further divided into an anterior, middle, and poster subregions, each with distinct neural connections and functions. The connection between conservatism and insular volume is most often attributed to its role in processing disgust, but the insula is recruited in numerous variegated functional processes. For example, the insula has been implicated in such wide-ranging processes as sensorimotor functions, socio-emotional processing, cognitive processing, and olfactory and gustatory functions (Uddin et al. 2017). To illustrate the scope insular functions, sensorimotor functions may include the regulation of autonomic function, interoception, the somatic processing of pain, auditory processing, and vestibular responses, while socio-emotional processing may pertain to the processing of emotional experiences, subjective feelings, and empathy (Uddin et al. 2017). One of the most consistent findings is that the insula is involved in cognitive functions like the detection of novel stimuli, in addition to other salience processing tasks (Uddin et al. 2017).

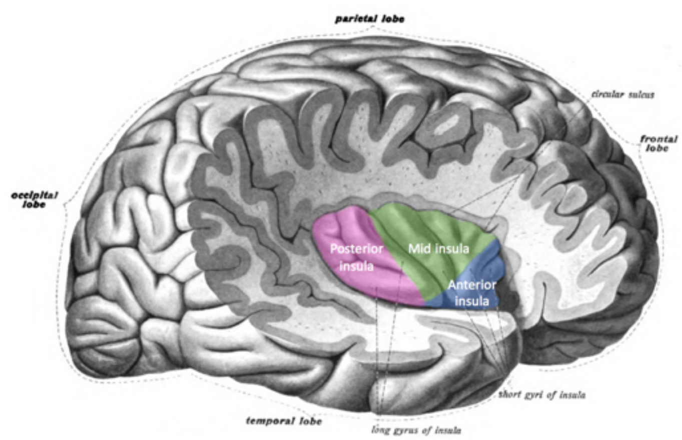

Figure 2. Anatomy of the insula (Schappelle, 2017).

The left insula specifically has been associated with myriad functions from the cognitive to the emotional. In lesion studies, the left insula has been shown to have important effects on executive set-switching, a critical component of flexible attention switching (Varjačić et al. 2018). Set-switching refers to one's ability to subconsciously shift attention between tasks, and deficits in executive set-switching are commonly noted among both acute and chronic stroke sufferers (Varjačić et al. 2018). In this manner, the insula appears to be an integral region in the regulation of goal-directed behavior. Still other studies have found an association between emotional intelligence and the left insula. Greater emotional intelligence was correlated with greater left insula activity during social judgments of fearful faces, but lower activity during social judgments of angry faces (Quarto et al. 2016).

Clearly, the breadth of functional utilities from the sensorimotor to high-level decision-making to emotional processing makes the insula a complex and heterogeneous neural region. The insula also happens to be one of the least understood brain regions (Uddin et al. 2017). Taken together, it is entirely possible that the link between the left insula and conservatism is distinct from the link between the left insula and political extremism. It is possible that while conservatives display greater left insular volume due to a disgust processing pathway, extremists have less left insular volume due to a cognitive, sensorimotor, or emotional pathway.

This study also has important limitations that may be reflected in this unexpected finding. Most importantly, the sample is relatively small and imbalanced between extremists and moderates. With the vast majority of subjects self-identifying as neither ideological or partisan orientation, there is an increased potential for skewed or non-representative results. Moreover, since only 1 subject identified as strongly Republican, the insula findings may be more representative of strong Democrats than extreme political attachment overall. As a secondary analysis, strength of ideology was operationalized as a continuous variable to avoid losing data by dichotomization. Results maintained the significance and directionality of the prior analysis, and therefore, provide additional evidence in favor of a negative relationship between left insula volume and strong ideological attachments.

It is also worth noting that the underrepresentation of conservatives/Republicans within this sample is commonplace in neuroimaging studies published to date. Even in Kanai et al.'s (2011) sample of 90 subjects, there were no participants who identified as "very conservative." Other studies have had similarly low or absent numbers of conservative participants (Pedersen et al., 2018), despite an explicit focus on differences between liberals and conservatives, or conservatism more generally. While there is room for improvement in sample balance, this study is not an outlier with respect to this measure.

The sample was also exposed to considerable trauma and in a hospital setting prior to the imaging acquisition. Although the groups were largely similar in instruments designed to measure the effects of such trauma, it cannot be ruled out definitively that exposure to trauma has influenced brain regions differentially between the political groups. There may be an interactive effect of exposure to trauma on ideology or partisanship, such that one group is more, or differently, affected. This interactive effect may have downstream consequences on neural structure or function. This limitation, in addition to the small and imbalanced sample, may help to explain why no differences in other regions of interest were detected.

Still, this sample is more diverse and representative than the majority of political imaging studies. Political science, and all social sciences, should strive to recruit more racially, ethnically, aged, and sexually diverse samples. This would provide a more accurate representation of the American population than the typical sample of white, college-aged students. That the majority of respondents were *not* considered extreme in their degree of political attachments is reassuring, particularly in an increasingly polarized and politically divided nation. This study should encourage the use of demographically representative samples in neuroimaging research, and all studies of political phenomena.

Despite the inconsistent results, the findings here set a pathway for future research into the biological differences between political extremes and moderates. Some structural differences were noted, but greater sample sizes with more extremists would be beneficial, as long as diversity was maintained. Replicating the study in a non-trauma exposed sample would also be informative to properly exclude trauma as a confounding variable. In the broadest terms, future political science research should endeavor to incorporate powerful methodologies like neuroimaging to improve our understanding of political ideology, partisanship, and strength of political group attachments.

Chapter Three: Political Attachment and the Brain

Introduction

Political polarization, both ideological and affective, has been steadily growing in the United States in recent decades (Abramowitz 2010; Iyengar et al. 2019; McCarty 2015). While ideological polarization refers to the increasing distance between Democrats and Republicans on political issues, affective polarization reflects an increasing dislike between partisans (Mason 2018). Distinct from issue-based conflict, affective polarization is driven by social identities, which promote ingroup favoritism and outgroup derogation (H. Tajfel and Turner 1979; Henri Tajfel 1970). The growth of affective polarization between both Democrats and Republicans and liberals and conservatives has already produced profound societal and governmental consequences, and it shows no signs of stopping.

In order to address the negative impacts of affective polarization, political group attachments must be fully understood; that is, the foundational causes of variation in strength of ideological or partisan attachment must be explained. Why are some individuals political extremists, wherein they display extreme attachment to their political group, while some individuals are political moderates, with weak or no strong attachments to any political group? One of the most promising avenues for this area of research is in biopolitics: the study of genetic and neurobiological mechanisms of political attitudes and behavior. Through biopolitics, the biological underpinnings of social group attachment can be elucidated to help answer critical questions about political attachments in a polarized environment. That is, instead of inquiring into the effects of political attachments, it is possible to examine the foundations of political attachments.

Biopolitics research has already contributed to the conceptualization of Democrats and Republicans or liberals and conservatives. From a genetic perspective, ideology has been found to have a strong genetic component (Alford, Funk, and Hibbing 2005; Martin et al. 1986), and political behaviors like voting have been shown to vary, at least in part, based on genetic markers (Dawes and Fowler 2009; J. H. Fowler, Baker, and Dawes 2008). Studies of the neurobiological bases for political orientations have yielded similarly impressive results. For example, Kanai et al. (2011) demonstrated that there are significant differences in the volumes of several neuroanatomical regions when comparing liberals and conservatives. Neural activity in some of these same brain regions were also found to differ based on partisanship (Schreiber et al. 2013), and when viewing and evaluating political candidates (Kaplan, Freedman, and Iacoboni 2007; Knutson et al. 2006) or threatening stimuli (Mills et al. 2016b; Pedersen, Tugan Muftuler, and Larson 2018).

While extant biopolitics literature has provided empirical support for a biologically based approach to studying political group membership, no studies to date have examined differences in the strength of political attachment. Given the evolutionarily integral role of group attachment throughout human history, it is expected that variation in strength of ideological or partisan attachment will be reflected in biological differences. Revealing the biological bases of strength of ideological and partisan attachment may, in turn, aid in effectively coping with the consequences of affective polarization. In the same way that effective interventions can ameliorate mental health disorders by capitalizing on neural plasticity (Hofmann et al. 2012; Ribeiro Porto et al. 2009), it may be possible to target and deploy mediating factors in the development or maintenance of extreme political attachments.

Polarization and its Consequences

The conceptualization of partisanship or ideological orientation as a social identity has existed within the political science literature for decades (Campbell et al. 1960; Greene 1999), but more recent research has demonstrated how political identification has contributed to both the causes and consequences of polarization (Finkel et al. 2020; Iyengar et al. 2019; Iyengar, Sood, and Lelkes 2012; Mason 2018; West and Iyengar 2022). According to social identity theory, social identities are internalized social categories that are integral to one's overall self-concept (H. Tajfel and Turner 1979; Henri Tajfel 1970). Individuals instinctively perceive themselves as members of social groups, and these perceptions exert powerful impacts on one's sense of self. Through the process of social identification, group membership activates two related ingrained affective responses: in-group favoritism and out-group negativity. The extent to which inter-group prejudice occurs is subsequently reliant on the salience of a given identity at a particular point in time; as the social identity becomes more salient, the bias in beliefs about both the in-group and the out-group grow (H. Tajfel and Turner 1979; Henri Tajfel 1970).

Partisan or ideological social identities are especially salient for two reasons. First, these identities are generally acquired at an early age and persist throughout the life cycle. Second, political campaigns and partisan news outlets have become nearly constant fixtures of American political life, explicitly and implicitly reinforcing the divides between political groups (Iyengar et al. 2019). Taken together, political groupings are both stable and consistently relevant social identities. Given the importance of partisan and ideological group memberships, it is not surprising that society has begun to experience some of the negative consequences of strong political identities; namely, affective polarization.

Affective polarization refers to the increasing dislike between rank-and-file partisans (or ideologues) within the electorate, rather than focusing on policy or issue differences between groups. The rise in affective polarization coincided with the onset of political sorting, which further deepened the distinctions between political groups (West and Iyengar 2022). As political party and political ideology became more aligned, other social identities (*e.g.*, race, religion) similarly sorted into their respective political groupings. The decline in cross-cutting identities heightened the salience of political identities in a reciprocating cycle of escalating affective polarization (Mason 2015b). Now, Republicans and Democrats, or conservatives and liberals, display markedly high levels of animosity, distrust, and ill will toward their political out-groups, and this division is no longer dominated by differences issue preferences alone.

As a result of growing affective polarization, traditionally "political" divisions have extended beyond the realm of politics and into broader societal interactions. For example, political group attachments now influence romantic relationships and friendships. Over the past 50 years, the percentages of parents who would be unhappy if their child married someone of the political out-group has risen about 35%, an effect that is greater among Republicans than Democrats (Iyengar et al 2012). Studies have even found that individuals perceive members of their political in-groups as more physically attractively than members of the political out-group (Nicholson et al. 2016). It stands to reason that partisanship or ideology represents a greater system of values and a broader worldview, which in turn influence choices regarding social interactions.

Affective polarization has also been shown to impact other modalities of behavior, including economic concerns. In one study, taxi drivers were found to charge members of the political out-group higher rates than in-group members, though an interactive effect between partisanship and ethnicity was also present (Michelitch 2015). Other studies showed that Democratic job candidates were more likely to receive callbacks in Democratic counties than Republican job candidates (Gift and Gift 2015), people are less willing to accept gift cards from companies who donate to Political Action Committees supporting the opposing party (Panagopoulus et al. 2016), and Democratic and Republican physicians provide different advice to patients on politicized health issues like abortion (Hersh and Goldenberg 2016). Clearly, the consequences of affective polarization have had significant spillover effects in other areas of social interactions, with potentially damaging results. Any positive impact (*e.g.*, spurring political activity) appears to be offset by difficulties governing, a lack of societal cooperation, and rampant hostility and aggression toward the political out-group.

Biology, Imaging, and Political Identification

While there is widespread recognition that political animus is a normatively negative trend, the innate and deeply rooted nature of the human response to social identification makes affective polarization particularly challenging to overcome. One currently underutilized approach to understanding and ameliorating affective polarization is biopolitics. By acknowledging and appreciating the evolutionary importance of social identification, a biopolitical framework for strength of partisan or ideological attachment could help generate insight into how best to conceptualize and confront affective polarization. The vast literature examining the *effects* of polarization can only begin to reveal potential avenues for reduction; to address the foundations of political attitudes and behavior, it is necessary to move beyond behavioralist or rational choice theories and into a more integrated paradigm that includes the basis of all human behavior: the brain. Only through thoroughly mapping the roots of political group attachment can that bond be lessened, reversed, or prevented when necessary.

Biopolitical research has already begun to link political identity with biological mechanisms. For example, in a sample of subjects with strong political beliefs, political attitudes were highly correlated with physiological traits. Specifically, liberals displayed reduced physiologic reactions in response to threatening stimuli when compared to conservatives (Oxley et al. 2008). This finding was consistent across measures of skin conductance and orbicularis oculi startle blink electromyogram responses, both of which operate in an automatic and involuntary manner. In response to threat, the sympathetic nervous system is activated, and skin conductance and startle blink responses increase unconsciously as a reaction to arousal, attention, or fear. The basic biological pathway from threat to physiological response is ubiquitous across individuals, but there is variation in perceptions of, and sensitivity to, potential threats.

However, the correlation between physiological traits and political attitudes does not offer conclusions regarding causality. While it is reasonable to theorize that specific components of individual variation in general biology may encourage identification with a given political orientation, it is equally plausible that the adoption of a particular political orientation may influence physiologic traits. The most likely paradigm is that a combination of genetics and socialization shape an individual's neuroanatomy, which then guides one's response to threats and subsequent physiological response. The biological basis of physiological traits is then associated with political identification at an innate, organic level.

To gain a deeper understanding of the relationship between biology and political identification, functional neuroimaging provides a method to map political attitudes and behavior onto the brain. Functional magnetic resonance imaging (fMRI) has been used increasingly since the late 1990s, when neuroscientists were able to show that specific functions were localized in discrete brain regions or structures (Schreiber 2017). Since then, fMRI has become the basis of cognitive science, but political scientists have only begun to examine the connections between neural activity and political attitudes or behaviors.

Functional imaging operates by taking a series of images that permit the detection of changes in cerebral blood flow. Specifically, researchers look for changes in blood oxygen level dependent (BOLD) signals, which vary as oxygenated blood is pumped into the brain and deoxygenated blood leaves the brain. Neural activity is correlated with changes in BOLD signals because neurons utilize oxygen as part of a metabolic process. So, as neural activity increases in a particular region of the brain, there is a corresponding increase in oxygenated blood flow. The cells then consume the oxygen in the hemoglobin and there is a resulting deoxygenation of the neural tissues. Oxygenated hemoglobin displays different magnetic properties than deoxygenated hemoglobin, and that is how fMRI is able to detect these subtle differences. These changes are then analyzed with respect to carefully timed stimuli presented to subjects in the magnetic resonance imaging machine to determine which neural regions activate during which cognitive processes.

Extant neuroimaging of political phenomenon is limited, but promising. For example, while structural imaging studies have demonstrated that liberals and conservatives differ in brain volume in four regions (the right amygdala, the left insula, the right entorhinal cortex, and the anterior cingulate cortex) (Ryota Kanai, Feilden, et al. 2011), Schreiber et al. (2013) were able to link these structural differences with functional differences. During a risk-taking task, Democrats showed significantly greater activity in the left insula, and Republicans showed significantly greater activity in the right amygdala (Schreiber et al. 2013). Not only do these conclusions support the structural imaging findings, but they also correspond with well-established cognitive and psychological differences between liberals and conservatives. Conservatives have more intense reactions to threatening, fearful, or negative stimuli than liberals on average (Hibbing, Smith, and Alford 2014), and the amygdala is a critical brain structure in processing emotions like fear. It appears that liberals and conservatives engage in distinct cognitive processes when evaluating risk, and these processes are represented in biological differences between these groups. Most notably, activation in these two brain regions is a better predictor of partisanship than traditional models relying on socialization (Schreiber et al. 2013).

In another study, neural activity was recorded as subjects viewed and evaluated the faces of presidential candidates (Kaplan, Freedman, and Iacoboni 2007). Results suggest that neural activity is contingent on political identification and negative emotions are regulated through cognitive control networks. When subjects viewed a candidate from the opposing party, cognitive control was activated in regions like the dorsolateral PFC, the anterior cingulate, the insula, and the anterior temporal poles (Kaplan, Freedman, and Iacoboni 2007).

Furthermore, this activation correlated with subjects' self-reported feelings about the candidates; the more negatively the subject felt about the opponent and the more positively they felt about their own candidate, the greater the neural activity discriminated between the two candidates faces (Kaplan, Freedman, and Iacoboni 2007). Importantly, this study indicates that not only does political identification matter, but strength of political identification may also be associated with neurobiology.

Extremism and Neurobiology

There is reason to believe that political extremism, or strength of partisan or ideological attachment, may correspond to individual variation in biological structures and processes in a similar manner to ideological or partisan identification. For example, in a functional neuroimaging study of strong partisans only, Westen et al. (2006) find a neurobiological basis for motivated reasoning. Motivated reasoning describes the processes by which motivational biases subconsciously regulate judgments to minimize negative affective states and maximize positive affective states (Westen et al. 2006). When subjects were presented judgments about a preferred candidate versus an opposing candidate, motivated reasoning was associated with neural activity in the ventromedial prefrontal cortex, the anterior cingulate cortex, the posterior cingulate cortex, the insular cortex, and the lateral orbital cortex. These regions are distinct from those activated in so-called "cold" reasoning tasks and conscious emotional regulation (Westen et al. 2006). Since strength of political identification is associated with motivated reasoning (Lodge and Taber 2013), the results of this study imply that political extremists may present with differential cognitive functioning compared to political moderates.

That is, extremists are more prone to motivational biases than moderates, and these biases appear to be correlated with distinct neural functioning.

Another study of subjects with strong political views reveals consistent results. When political extremists were presented with arguments that contradicted their political beliefs, neural activity increased in the default mode network (Kaplan, Gimbel, and Harris 2016). The default mode network is a set of brain structures that may be the neurobiological basis of the self, and it is associated with detachment from the external environment. Results revealed that greater belief resistance yielded increased neural activity in the dorsomedial prefrontal cortex and decreased activity in the orbitofrontal cortex (Kaplan, Gimbel, and Harris 2016). As expected, non-political beliefs did not present the same level of defensiveness from these political extremists.

Missing from these functional MRI studies is an explicit test of neurobiological variation based on strength of partisan or ideological attachment. The biological and evolutionary importance of social identity provides ample support for the notion that political attachment is associated with biological structure and function, and the growing strength of contemporary political identification has made it more important to understand than ever before. In order to form a hypothesis regarding the specific functional neurobiological differences to be expected between political extremists and political moderates, the extremism hypothesis offered by van Prooijen et al. (2015) may be reviewed.

The extremism hypothesis suggests that strong liberals/Democrats and strong conservatives/Republicans have more similarities than previously understood. More specifically, it proposes that both groups will share traits traditionally associated with conservatism: “the rigidity of the right.” The rigidity of the right is a form of motivated social cognition whereby conservative attitudes are formed and maintained to decrease feelings of fear or uncertainty (van Prooijen et al. 2015). It is because of this desire to reduce fear that conservatives generally subscribe to policies promoting order, structure, and resistance to change. However, the psychological motivation to combat fear and uncertainty is not exclusive to strong conservatives; it may be a guiding influence on strong liberals as well.

Empirical evidence supports the idea that strong ideologues or partisans on either end of the political spectrum seek to reduce fear and uncertainty. Both groups tend to process information with low cognitive complexity. That is, political extremists think in terms of good versus bad and black versus white (Toner et al. 2013). This is often coupled with a tendency to perceive themselves as belonging to the correct side of a political debate, with little room for admission of being incorrect (Toner et al. 2013). Extremists of both sides have also been shown to display more prejudice or intolerance than political moderates, though liberals/Democrats and conservatives/Republicans are biased toward different target groups (Brandt et al. 2014; Chambers, Schlenker, and Collisson 2013; Crawford and Pilanski 2014; Wetherell, Brandt, and Reyna 2013).

Considering the evidence outlined by the extremism hypothesis, strong ideologues or partisans may share common cognitive processes, and therefore, common neurobiological functioning. In a neuroimaging task involving the down-regulation of negative affect through cognitive reappraisal then, political extremists would be expected to be more impaired by negative information. Strong ideologues or partisans would share an automatic, selective attention toward negative or threatening stimuli and be less able to reappraise negative stimuli successfully. When compared to political moderates, the established neural circuitry of successful reappraisal would not be apparent among extremists.

H1: Strong liberals and strong conservatives will be more impaired by negative information than political moderates in an emotion regulation neuroimaging task.

H2: Strong Democrats and strong Republicans will be more impaired by negative information than political moderates in an emotion regulation neuroimaging task.

It is worth noting that while strong liberals/Democrats and strong conservatives/Republicans are expected to share some common neurobiological features when compared to political moderates, this does not discount the myriad established characteristics in which the right and the left differ. Liberals and conservatives and Democrats and Republicans have different worldviews, personalities, and even artistic preferences (Hibbing, Smith, and Alford 2014), and these distinctions are not negated by the extremism hypothesis. Instead, it is argued that the relationship between group membership and fear or uncertainty is quadratic; strong liberals/Democrats and strong conservatives/Republicans share this psychological goal of avoiding fear, despite differing on other motivational approaches.

Methods

Sample

To test these hypotheses, a sample of participants was obtained through hospital admissions or injury-related visits to midwestern Level 1 Trauma Center. Recruitment occurred either in-person or via phone call after patient discharge. Potential participants were provided with study details and a first visit was scheduled. Demographic characteristics for enrolled participants was derived through medical chart abstraction and the trauma registry.

The study cohort was determined through the utilization of the Injured Trauma Survivor Screen (ITSS). The ITSS is a brief survey given to patients presenting with traumatic injury in order to measure the risk for developing post-traumatic stress disorder (PTSD) and depression one month post injury (Hunt et al. 2021). An ITSS score of two or a more indicates a PTSD risk-positive patient. Only patients who are risk-positive for the development of PTSD were be included in the study (approximately 100 patients).

Procedure

During the first visit, consent to participate was obtained. Participants completed a series of questionnaires and had blood drawn (5mL). Questionnaires included: PCL-5, ETV-C, PEDQ, psychiatric history, substance abuse, CTQ, CESD, DERS-SF, DSI-SS, SBQ-R, MTOP COVID-19 Inventory, the Milwaukee Trauma Outcomes Project (MTOP) Demographics Inventory, and the LEC. Differences in demographic or trauma-based characteristics were analyzed.

Of the approximately 100 participants who screened risk-positive on the ITSS, a goal of 50 participants was set for the neuroimaging protocol. This group consisted of those who scored highly on the PTSD diagnostic tool the PCL-5 (PCL-5>30) and those who score low on the PCL-5 (PCL-5<10). Qualifying participants were invited to participate in the MRI scan, and if eligible, a separate visit was scheduled.

Two to four weeks after the date of trauma, MRI scans were conducted on participants in this portion of the study. The scan took approximately one hour, and participants were compensated with $100. Pregnant women were not permitted to participate in the imaging component of the study. During the MRI session, participants first reviewed the safety questionnaire to reaffirm that it is safe for them to enter the scanner. They put in earplugs and laid on the table with their head in a plastic support. Respiratory bellows and pulse oximeter were used to record physiological data. A button box was placed on the participant's lap for the scanner tasks, and a squeeze ball and instructions were provided in case of emergency. Participants also wore earphones to communicate with research staff during the tasks.

A resting state scan was first conducted. While lying still, data on resting state functional brain activity was collected. Participants were not given any task to complete during this portion of the scan. Instead, they were asked to remain awake with their eyes open.

Two specific tasks were then completed in the scanner while brain activity data were collected. First, the Emotion Regulation Task (ERT) allows for the study of down-regulation of negative affect through cognitive reappraisal (Fitzgerald et al., 2016; Parvaz et al., 2012). There were two runs of this task, taking 13 minutes in total. Negative (32 images) or neutral images (16 images) were grouped, with each block consisting of four images. The images were derived from the International Affective Picture System (IAPS; Lang et al., 2008). Within blocks, each image is shown for five seconds (total block time of 20 seconds). Prior to each block, participants are instructed to either "look" or "reappraise" by a screen that remains for five seconds. To "look" means that participants should continue viewing the picture without attempting to change their emotional reaction, but to “reappraise” asks participants to decrease negative affect by making the image appear less negative.

Participants were trained in the cognitive reappraisal technique before entering the scanner. During training, research staff asked participants to “reappraise” by envisioning the depicted scenario in a less negative way. For example, an image of people crying outside a hospital could be out of joy for the birth of a new baby rather than the injury or death of a loved one. To “look,” participants are trained to view the images in a passive manner, without trying to change their affective reaction. Participants engaged in eight practice trails with images not used in the task. To ensure the participants understand the reappraisal task, research staff asked them to verbalize their emotional reappraisal strategies and provide feedback during the practice rounds.

Half of the negative images were preceded with instructions to “look,” while the other half asked respondents to “reappraise.” All neutral blocks were preceded with instructions to “look.” Following each block, participants rated how negative they felt on a 5-item Likert scale (5=most negative). There was then a 20-second rest period, in which participants were instructed to relax and stare at a white fixation on a black screen. A total of 6 blocks were used within each run (4 negative blocks, 2 neutral blocks). Block order was pseudo-randomized for each participant.

Next, participants engaged in the Emotional Stroop task, which measures attentional control. The Stroop task has previously been found to be correlated with ideological orientation (Carraro, Castelli, and Macchiella 2011). The task took approximately 10-15 minutes to complete. Participants were asked to read an affectively charged word like “fear” or “happy” written on top of either an image of a face depicting the matching emotion, or an image of a face depicting an incongruent expression. For example, the word may say “happy,” but the facial expression indicates fear. To complete the task, participants must indicate the emotion depicted by pressing the left button on the button box for a fearful face or the right button for a happy face. To respond correctly, they must ignore the word on the face; this is particularly challenging because reading is an automatic process and participants must inhibit the tendency to respond based on the word. Participants were able to practice the task first.

Survey Measures

Political Affiliation

Political affiliation and political ideology were collected at visit one. Respondents were asked to identify as either a strong Republican, a weak Republican, neither a Republican nor a Democrat, a weak Democrat, or a weak Republican. Respondents were also asked to select their ideological orientation: strongly conservative, weakly conservative, neither conservative nor liberal, weakly liberal, or strongly liberal. Subjects are then classified as either strong partisans or weak partisans, and either strong or weak ideologues. Secondary analyses were also conducted in which strength of ideological or partisan attachment was treated as a continuous variable, with 1 indicating neither affiliation, 2 indicating a weak affiliation, and 3 indicating a strong affiliation.

Demographics and Injury Characteristics

Respondents were asked to indicate their age, sex at birth, race, and ethnicity. Mechanism of Injury (MOI) and Injury Severity Score (ISS) were also collected. MOI was coded as either: motor vehicle crash/pedestrian struck/motorcycle crash, gunshot, stab, fall, crush, domestic violence/assault/altercation, or other. ISS was calculated based on the Abbreviated Injury Score of the 3 highest anatomical areas of injury.

PTSD Checklist for DSM-5 (PCL-5)

The PCL-5 is a self-report measure which can be utilized to screen or track posttraumatic stress disorder symptoms. It is a 20-item survey asking respondents how much a particular symptom has bothered since the time of the traumatic experience. Each question ranges from 1 ("not at all") to 5 ("extremely), for a possible total summed score of 80. Scores for each symptom cluster according to the DSM-5 can also be calculated.

Clinician-Administered PTSD Scale for DSM-5 (CAPS -5)

The CAPS-5 is the gold standard assessment for posttraumatic stress disorder. It is a clinician- or paraprofessional- administered structure interview with 30 questions. Survey items measure the 20 symptoms of posttraumatic stress disorder and can be used to indicate current or lifetime diagnosis of PTSD. It can also be utilized to describe the onset, duration, and severity of symptoms, as well as changes in symptoms.

Data Acquisition and Preprocessing

Imaging data was acquired on a GE Signa Premier 3T scanner with a 48-channel head coil and high-speed gradients. Functional images were preprocessed to drop the first 2 volumes, time series data was realigned due to movement, and slice-timing correction was applied based on 30 slices assuming a bottom-up interleaved acquisition. Images were then normalized to MNI/coregistration to T1 and skull-stripping. Finally, spatial smoothing was conducted using 5mm FWHM kernels.

Preprocessed functional neuroimaging data was then subjected to a first-level analysis. In the first-level analysis, general linear models were applied to the time series data and convolved on the canonical hemodynamic response function with a 128 s high-pass filter. Nuisance regressors are included to correct for motion artifacts. Trials for conditions "look-neutral," "look-negative" and "reappraise" were modeled separately and effects were estimated for each voxel. Two contrasts of interest were calculated: 1) maintain, which contrasted activation during looking at a neutral image and a negative image, and 2) reappraise, which contrasted activation during looking at a negative image and reappraising the negative image. All preprocessing and first-level analyses were conducted in Matlab (v.2019) and SPM (v.12).

Analysis

To test for differences between strong and weak political ideologues and partisans in demographics or injury-related characteristics, bivariate analyses were conducted. Wilcoxon rank sum tests were utilized to analyze non-parametric continuous variables, while Fisher's exact tests were used to analyze categorical variables with low cell sizes. Alpha was set at $p<0.05$, and all tests were two-tailed. Statistical analyses were conducted in R Statistical Software (v1.2.5042; R Core Team 2021).

Second-level, or group-level analyses were conducted on preprocessed functional neuroimaging data. For the primary analysis, four separate two-sample t-tests were run to examine differences in each contrast (maintain and reappraise) for ideology and partisan attachment separately. For the secondary analyses, one-sample t-tests were conducted for each contrast for ideology and partisanship separately. An uncorrected p-value of $p<0.001$ was used in conjunction with cluster-defining thresholds for a false positive rate of 0.05. Second-level analyses were conducted in SPM (v.8).

Results

Of the 39 subjects who were scanned, 33 had usable data on the Emotion Regulation Task. Most subjects had weak self-reported political attitudes (n=25) that were either somewhat liberal/conservative (n=4 and n=3) or neither liberal nor conservative (n=18). Only 1 subject reported very conservative attitudes, while 7 reported very liberal attitudes. Likewise, the majority of subjects were categorized as having weak political partisan attachment (n=27) compared to strong partisanship (n=6). A total of 23 subjects indicated they were affiliated with neither the Democratic nor Republican party, while 2 were weakly Republican and Democratic each. There was 1 strong Republican and there were 5 strong Democrats.

Sample descriptive statistics are reported in Table 8. The sample was split roughly equally between males and females (52% to 48%, respectively), with the majority of subjects reporting their race was Black or African American (61%). Injury Severity Score is reported, but is largely missing for the sample (29/33). The most common mechanism of injury was motor vehicle crash/motorcycle crash/pedestrian struck (76%). The median Injured Trauma Survivor Scale was high at 7, but this is concordant with a sample of posttraumatic stress disorder risk-positive subjects.

Table 8. Sample Characteristics

Characteristic	**N = 33**[1]
Age	29.00 (25.00, 39.00)
Sex	
Female	16 (48%)
Male	17 (52%)
Race	
2+	4 (12%)
AI or Alaskan	1 (3.0%)
Black	20 (61%)
White	8 (24%)
Hispanic/Latino	
Hispanic/Latino	2 (6.7%)
Not Hispanic/Latino	28 (93%)
Unknown	3
Injury Severity Score	8.00 (5.00, 11.50)
Unknown	29
Mechanism of Injury	

Characteristic	N = 33[1]
DV/Assault	3 (9.1%)
Fall	2 (6.1%)
MVC/Struck/Motorcycle	25 (76%)
Other	2 (6.1%)
Stab	1 (3.0%)
ITSS Total	7.00 (5.00, 8.00)
PCL-5 Total Score	51.00 (39.00, 60.00)
CAPS-5 Total Score	16.00 (7.50, 22.75)
Unknown	7
CAPS-5 PTSD Diagnosis	9 (35%)
Unknown	7
Strength of Ideology	
Strong	8 (24%)
Weak	25 (76%)
Strength of Partisanship	
Strong	6 (18%)
Weak	27 (82%)

[1] Median (IQR); n (%)

Table 9 displays differences in subjects with strong and weak political ideologies. The two groups are statistically similar in age, sex, race, and ethnicity. There are also no differences between strong and weak political ideologues in MOI, ITSS scores, PCL-5 scores, and CAPS-5 diagnoses at 6 months post-trauma. While it cannot be ruled out that trauma affects the brains of strong and weak political ideologues differentially, these tests for differences in trauma-related indicators suggests that the functional imaging data will not be contaminated by an unequal distribution of trauma exposure.

Table 9. Strong and Weak Political Ideology

Characteristic	**Strong**, N = 8[1]	**Weak**, N = 25[1]	**p-value**[2]
Age	29.00 (24.75, 42.50)	29.00 (26.00, 37.00)	0.933
Sex			1.000
Female	4 (50%)	12 (48%)	
Male	4 (50%)	13 (52%)	
Race			1.000
2+	1 (12%)	3 (12%)	
AI or Alaskan	0 (0%)	1 (4.0%)	
Black	5 (62%)	15 (60%)	
White	2 (25%)	6 (24%)	
Hispanic/Latino			0.418
Hispanic/Latino	1 (14%)	1 (4.3%)	
Not Hispanic/Latino	6 (86%)	22 (96%)	
Unknown	1	2	
Injury Severity Score	5.00 (5.00, 5.00)	11.00 (8.00, 12.00)	0.637
Unknown	7	22	
Mechanism of Injury			0.665
DV/Assault	0 (0%)	3 (12%)	
Fall	0 (0%)	2 (8.0%)	
MVC/Struck/Motorcycle	7 (88%)	18 (72%)	

Characteristic	**Strong**, N = 8[1]	**Weak**, N = 25[1]	p-value[2]
Other	1 (12%)	1 (4.0%)	
Stab	0 (0%)	1 (4.0%)	
ITSS Total	6.00 (3.00, 8.00)	7.00 (5.00, 8.00)	0.373
PCL-5 Total Score	56.50 (47.00, 64.00)	50.00 (39.00, 59.00)	0.388
CAPS-5 Total Score	14.00 (8.00, 23.00)	16.00 (8.50, 22.50)	0.931
Unknown	1	6	
CAPS-5 PTSD Diagnosis	3 (43%)	6 (32%)	0.661
Unknown	1	6	

[1] Median (IQR); n (%)

[2] Wilcoxon rank sum test; Fisher's exact test

In Table 10, the same variables are assessed for differences between strong and weak political partisans. Again, there were no statistically significant differences between the groups with respect to either demographic or injury-related characteristics. Baseline PCL-5 scores were higher in the strong partisan group compared to the weak or no partisan affiliation group (64 (59-64) vs. 49 (38-58)), but this difference did not reach the threshold for statistical significance (p=0.05). Nonetheless, it is worth noting that strong partisans may have been more effected by exposure to trauma shortly after the injury.

Table 10. Strong and Weak Political Partisanship

Characteristic	**Strong**, N = 6[1]	**Weak**, N = 27[1]	p-value[2]
Age	30.00 (24.50, 39.50)	29.00 (26.00, 38.00)	0.907

Characteristic	**Strong**, N = 6[1]	**Weak**, N = 27[1]	**p-value**[2]
Sex			0.398
Female	4 (67%)	12 (44%)	
Male	2 (33%)	15 (56%)	
Race			0.622
2+	0 (0%)	4 (15%)	
AI or Alaskan	0 (0%)	1 (3.7%)	
Black	5 (83%)	15 (56%)	
White	1 (17%)	7 (26%)	
Hispanic/Latino			0.310
Hispanic/Latino	1 (20%)	1 (4.0%)	
Not Hispanic/Latino	4 (80%)	24 (96%)	
Unknown	1	2	
Injury Severity Score	5.00 (5.00, 5.00)	11.00 (8.00, 12.00)	0.637
Unknown	5	24	
Mechanism of Injury			0.696
DV/Assault	0 (0%)	3 (11%)	
Fall	0 (0%)	2 (7.4%)	
MVC/Struck/Motorcycle	5 (83%)	20 (74%)	
Other	1 (17%)	1 (3.7%)	
Stab	0 (0%)	1 (3.7%)	
ITSS Total	7.50 (5.50, 8.75)	7.00 (5.00, 8.00)	0.604
PCL-5 Total Score	64.00 (58.75, 64.00)	49.00 (37.50, 58.00)	0.050

Characteristic	**Strong**, N = 6[1]	**Weak**, N = 27[1]	**p-value**[2]
CAPS-5 Total Score	22.50 (8.50, 37.75)	16.00 (7.75, 22.75)	0.434
Unknown	2	5	
CAPS-5 PTSD Diagnosis	1 (25%)	8 (36%)	1.000
Unknown	2	5	

[1] Median (IQR); n (%)

[2] Wilcoxon rank sum test; Fisher's exact test

Whole brain functional activity was analyzed next to test for differences in contrast between ideological and partisan political affiliations separately. Neural activity for ideological extremes vs ideological moderates was assessed in the maintain and reappraise conditions. The maintain condition contrasted hemodynamic response in the look-neutral vs look-negative blocks, while the reappraise condition contrasted hemodynamic response in the look-negative vs reappraise blocks. Contrasts were developed to test for areas of activation in which either extremes were greater than moderates, or moderates were greater than extremes. Only voxels meeting the $p<0.001$ peak-level threshold were analyzed. For the maintain contrasts, the maximum number of voxels in a cluster ranged from 1-8 ($t=4.52$, FWE $p=0.975$ and $t=4.28$, FWE $p=0.937$), but no differences in activation survived Family-Wise Error (FWE) rate corrections. Similar results were observed in the reappraise contrasts, with maximum number of voxels at 9 ($t=5.07$, FWE $p=0.724$ and $t=4.28$, FWE $p=0.999$). According to these results, strong ideological identifiers and weak ideological identifiers did not significantly differ in neural activation during either condition during the Emotion Regulation Task.

Using the same methods, no statistically significant differences in areas of functional activation were discovered when comparing extreme and weak political partisans. Contrasts were again run to test where extreme partisans displayed greater activation than moderates, and where moderate partisans displayed greater activation than extreme partisans. Results for the extremist greater than weak partisan contrast during the maintain condition showed a maximum number of 8 contiguous voxels (t=5.09, FWE p=0.629), while the contrast for weak partisans greater than extreme partisans showed a maximum number of only 2 voxels (t=3.68, FWE p=1.000). The reappraise condition contrasts had a maximum number of 10 voxels (t=4.43, FWE p=0.995 and t=3.67, FWE p=1.000), but no regions survived FWE corrections for multiple comparisons. Just as with ideological attachments, strength of partisan attachment does not appear to be related to neural activation during either the maintain or reappraise conditions of the Emotion Regulation Task.

Given the limitations of the imbalanced sample, in which 7 of the 8 strong ideologues were liberals, and 5 of the 6 strong partisans were Democrats, a secondary analysis was conducted in which strength of ideological or partisan attachment was treated as a score. Using a continuous variable, data lost through dichotomization is maintained. For ideology, subjects who identified as neither liberal nor conservative received a score of 1 (n=18), subjects who identified as weakly liberal or conservative received a score of 2 (n=7), and subjects who identified as strongly liberal or conservative received a score of 3 (n=8). Likewise, for partisanship, subjects who identified as neither liberal nor conservative received a score of 1 (n=23), subjects who identified as weakly liberal or conservative received a score of 2 (n=4), and subjects who identified as strongly liberal or conservative received a score of 3 (n=6).

Importantly, the group of weak identifiers was spit roughly equally between liberals and conservatives or Democrats and Republicans. With this operationalization, strength of ideological attachment was significantly related to sex ($p<0.001$), race ($p=0.006$), ethnicity ($p<0.001$), and CAPS-5 diagnosis at 6 months ($p<0.001$). Partisan affiliation was similarly related to sex ($p<0.001$), ethnicity ($p<0.001$), and CAPS-5 diagnosis at 6 months ($p<0.001$), though not race.

Functional imaging results were similar when analyzing ideology and partisanship separately. In the maintain condition, both groups were significantly and positively associated with activity in one region (MNI coordinates x=52, y=-64, z=14) with a 340-voxel cluster for partisanship ($t=6.38$, FWE $p=0.026$) and a 323-voxel cluster for ideology ($t=6.39$, FWE $p=0.025$). Voxels in this region correspond to the right inferior parietal lobule (IPL) according to the Human Brainnetome Atlas (Fan et al. 2016). In the reappraise condition, both groups were significantly and positively associated with activity in three regions. In the first region (MNI coordinates x=34, y=-84, z=14) strength of partisanship had a 2005-voxel cluster ($t=9.02$, FWE $p<0.001$) and ideology had a 1935-voxel cluster ($t=9.05$, FWE $p<0.001$). Voxels in this region correspond to the middle occipital gyrus (Fan et al. 2016). In the second region (MNI coordinates x=-30, y=-62, z=-14) partisanship had a 1438-voxel cluster ($t=8.76$, FWE $p<0.001$), and ideology had a 1349-voxel cluster ($t=7.85$, FWE $p<0.001$). This region corresponds to the fusiform gyrus (Fan et al. 2016). In the last region (MNI coordinates x=-2, y=18, z=54), partisanship had a 481-voxel cluster ($t=6.08$, FWE $p<0.001$), while ideology had a 459-voxel cluster ($t=8.59$, FWE $p<0.001$). Voxels in this final region correspond to the superior frontal gyrus (Fan et al. 2016).

However, when traditional covariates of age and sex were included in the analyses, none of the aforementioned voxel clusters of neural activity maintained their statistical significance. Since the continuous operationalization of ideological or partisan attachment was found to be significantly associated with sex, it was important to include this covariate to control for potentially confounding effects of sex-related differences in neural anatomy and functionality. Thus, the secondary analysis revealed the same null effects found with the dichotomized version of strength of attachment. During the Emotion Regulation task, neural activity did not significantly correlate with strength of political affiliation within this sample.

Discussion and Conclusions

In the first study to examine differences in neural signals between strong and weak political partisans in an emotion regulation task, no significant regions of activation were found. Although multiple regions met the single-voxel threshold of $p<0.001$, it is necessary in fMRI studies to adjust for multiple comparisons. The typical group-level analysis is created through a mass univariate analysis, in which a statistical test is run for each voxel on the brain map. Since datasets contain hundreds of thousands of voxels, controlling for false positives is essential for distinguishing true differences in neural activation from noise. Through this adjustment for multiple comparisons, regions that initially met the p-value thresholds fell outside of the range of statistical significance.

However, this lack of findings may be due to the imbalanced nature of the sample. In the strong political attachment groups, 8 subjects were available for analysis in the ideological group, and 6 were available for analysis in the partisan group. The overwhelming majority of subjects in either group identified as neither liberal/conservative or neither Democrat/Republican. Additionally, only 1 subject identified as strongly Republican or conservative. Considering this critical limitation, secondary analyses were conducted operationalizing strength of ideological or partisan attachment as a continuous variable. This rectified the data loss due to dichotomization, and as such, this scoring system included data from additional conservative or Republican subjects in the weakly affiliated group.

Results from the secondary analysis revealed areas of statistically significant neural activity, but these findings disappeared when controlling for the common confounders of age and sex. The consistent results between the two approaches may indicate a genuine lack of differences in neural activity based on strength of ideological or partisan attachment, or it may reflect overall limitations associated with the small sample size of the study. The lack of subjects identifying strongly with either political grouping, and especially the conservative or Republican groups, may obscure true differences between strong and weak ideologues or partisans, though standards for sample size in fMRI studies vary widely (Desmond and Glover 2002; Grady et al. 2021; Szucs and Ioannidis 2020).

For example, a recent meta-analysis of fMRI sample sizes and thresholds revealed that, of the 388 studies examined, nearly 36% had fewer than 25 subjects (Yeung 2018). Moreover, studies have also revealed that a substantial proportion of fMRI studies have been published without corrections for multiple comparisons, ranging from 6% (Woo, Krishnan, and Wager 2014) to an astounding 41% (Carp 2012). Therefore, despite the inherent limitations of this sample, it fits within the standard boundaries of a fMRI study sample size, and utilized the best available statistical approaches to maximize sensitivity and reduce false positives (Woo, Krishnan, and Wager 2014).

Another limitation specific to this sample of subjects appears on closer inspection of individual responses to the ideological and partisan measures. Several subjects identified as strongly liberal or conservative in ideology, but had corresponding responses of strongly Republican or Democratic in partisanship. While ideology and partisanship need not correlate 100% even with partisan sorting, it would be highly unusual for an individual to identify strongly with a partisan group, but not its ideological leanings. Furthermore, it would be even more unlikely that an individual would identify strongly with a given party while subscribing strongly to the opposing party's ideological disposition. Unfortunately, there is no way to determine the source of these discrepancies; they may be genuine, or they may be the result of reduced political sophistication or data collection error.

It is also possible that while strong or weak political attachments do significantly correlate with differences neural functioning, the Emotion Regulation Task is not the optimal paradigm to reveal such distinctions. Despite theoretical and empirical support for utilizing a task associated with emotion regulation to evaluate differences in neural functioning between these groups, other established emotion-based fMRI tasks should also be assessed in the future. Each paradigm rests on its own assumptions and implicates distinct neural circuitry involved, some of which may be associated with political attachments, and some of which may not. A lack of significant results in one particular paradigm, with one particular sample, does not provide sufficient evidence to reject a robust theoretical foundation.

Above all else, future biopolitics endeavors should concentrate on the replication and expansion of extant neuroimaging literature. Cognitive science overall suffers from a lack of replication, perhaps due to the cost prohibitive nature of- and access to- magnetic resonance imaging. Biopolitics then, is at an even greater disadvantage in the quest to generate reproducible results in diverse samples from around the country. It is too early to dismiss the potential for neural differences to exist between strong and weak political ideologues/partisans, and without additional work investigating this area in more balanced samples, few concrete conclusions can be derived from the results.

Chapter Four: Political Orientation and Emotion Regulation

Introduction

A large and ever-expanding body of research indicates that liberals and conservatives or Democrats and Republicans differ widely on important psychological and physiological indicators, in addition to explicitly political characteristics. Political ideology and partisan affiliation have been shown to correlate with psychological traits like authoritarianism (Adorno et al. 1950), agreeableness, openness to experiences, conscientiousness, extraversion or introversion, emotional stability or neuroticism (Jeffery J. Mondak and Halperin 2008), power, tradition, and universalism (Caprara et al. 2006; Schwartz 2007), among others. Physiological measures, including skin conductance, orbicularis oculi startle response (Oxley et al. 2008), and event related potentials (Amodio et al. 2007), have also been consistently associated with political divisions.

One of the most prominent and frequently reported differences between liberals and conservatives or Democrats and Republicans is termed "negativity bias." This concept refers to the finding that conservatives/Republicans have greater psychological and physiological reactions to negative or aversive stimuli than liberals/Democrats. Not only do conservatives react more strongly to negative stimuli than liberals, they have also been shown to direct more attention toward negative stimuli than liberals (Amodio et al. 2007; Hibbing, Smith, and Alford 2014; Pedersen, Tugan Muftuler, and Larson 2018). This bias toward negativity has also been linked to conservative values like prioritizing stability and reducing threats. In fact, some scholars suggest that negativity bias is a foundational division between ideological orientations, which then guides the political positions endorsed by each individual (Hibbing, Smith, and Alford 2014).

The conservative proclivity toward negativity bias has also been connected to variation in neurobiology. For example, liberals were found to have greater gray matter volume in the anterior cingulate cortex (ACC) compared to conservatives, and this region is associated with the ability to tolerate uncertainty (Kanai et al. 2011). This same study further demonstrated that conservatives had greater gray matter volume in the amygdala, a region known for its role in processing fear and threats (Kanai et al. 2011). Whole brain analyses additionally revealed significant differences in the left insula and right entorhinal cortex, which may also be involved in negativity bias, as they process disgust and negative memories, respectively (Ryota Kanai, Feilden, et al. 2011). The theoretical bases of these neuroanatomical distinctions and the replication of these findings in an independent sample of participants suggest that negativity bias is indeed a deeply rooted distinction between ideological or partisan orientations.

Despite the consistency with which negativity bias is attributed to conservatism, one yet unexamined area of potential insight is in relation to emotion regulation. One particular form of emotion regulation, reappraisal, specifically targets and attempts to reduce psychological and physiological reactions to negative stimuli. It is reasonable to expect that conservatives or Republicans may operate differently than liberals or Democrats on a neurobiological level during a task requiring emotional reappraisal of negative or aversive stimuli. Understanding these differences in the ability to regulate emotions through reappraisal may further connect political orientations to the basic biological mechanisms they represent

(Alford, Funk, and Hibbing 2005; J. H. Fowler and Dawes 2008; P. K. Hatemi, Funk, et al. 2009; Ryota Kanai, Feilden, et al. 2011; Settle, Dawes, and Fowler 2009).

Political Affiliation as Identity

Political affiliations, both partisanship and ideology, are powerful and increasingly salient social identities (Finkel et al. 2020; Greene 1999; Iyengar et al. 2019; Iyengar, Sood, and Lelkes 2012; Mason 2018). According to Social Identity Theory (H. Tajfel and Turner 1979; Henri Tajfel 1970), people define themselves according to their social groupings, and these groups shape attitudes and behavior. For example, partisanship guides political attitudes and behavior like voting preferences and attitudes on specific policies, as well as non-political phenomena, like perceptions, cognition, attentional control, and memory (Van Bavel and Pereira 2018). Ideology is similarly reflected in core predispositions based on genuine and durable beliefs, even if a fully integrated belief system is absent in most citizens (Chen and Goren 2016; Lelkes 2021).

While the relationship between partisanship and ideology has varied over time and across places, the correlation between political party and political ideology has grown stronger in recent decades (Sides and Hopkins 2015). Despite the fact that ideology has a genetic basis (Alford, Funk, and Hibbing 2005) and emerges early in life (Block and Block 2006; Fraley et al. 2012), studies have generally concluded that partisanship shapes ideology, rather than ideology shaping partisanship. That is, affiliation with a political party alters one's ideology to avoid cognitive dissonance or other averse psychological experiences (Van Bavel and Pereira 2018). With the growing concordance between the partisanship and ideology, political identities have superseded other groupings to become *the* most important identity to many Americans, with wide ranging consequences (Iyengar et al. 2019).

Many consequences of the strengthening of political attachments in a polarized environment are clear to the American public. Government functioning has decreased, gridlock is commonplace, and legislation is rarely passed with bipartisan support (Finkel et al. 2020; McCarty 2015). Other consequences are implicit, and less apparently the result of political identifications. Strong political group attachments have led to an increase in affective or social polarization, which has caused everyday citizens to become distrustful and derisive toward members of the opposing political party or ideological orientation (Iyengar et al. 2019; Mason 2015b, 2018). Choices in friendships, romantic relationships, and even professional colleagues are now heavily influenced by political attachment. Meanwhile, animosity, open hostility, and prejudice toward the outgroup has also heightened as a result of strong political identification (Finkel et al. 2020; Mason 2015b).

In order to fully comprehend the impact of political identities, the origin of such affiliations must be understood. From an evolutionary perspective, the human brain evolved specially functionalized mechanisms and regions to engage with others socially (Cosmides, Tooby, and Kurzban 2003; Tooby and Cosmides 1995). Specifically, human brains have evolved to find coalitional alliances or tribes, which fulfill basic psychological needs like belonging, positive distinctiveness, access to resources, epistemic closure, and other values (Baumeister and Leary 1995; Brewer 1991; Webster and Kruglanski 1994). Throughout human history, the need for group membership has created a biological foundation for our contemporary political affiliations.

With the biological bases of social identity in mind, it is easy to understand how social identities, and political identities in particular, can influence one's worldview. For example, it is not surprising that partisanship has been shown to affect political cognition and beliefs about political figures (Bartels 2002), political facts (Gaines and Kuklinski 2007) and even scientific issues (Kam 2005). However, partisanship has also been shown to affect basic neural functions unrelated to politics, like memory (Castelli and Carraro 2011; Frenda et al. 2013) and visual processing (Molenberghs et al. 2013). Based on this evidence, political identification appears to be deeply rooted in human biology. To further investigate these brain-based differences, neuroimaging offers one promising avenue to connect political identification with biological mechanisms.

Neurobiology of Political Divisions

Functional neuroimaging studies have become the foundation of cognitive neuroscience. This approach capitalizes on magnetic resonance imaging (MRI) devices' ability to detect changes in cerebral blood flow that correspond to neural activity. The blood oxygen level dependent (BOLD) magnetic signals reflect oxygenation levels in particular regions of the brain during tasks, such that specific functionality can be localized in discrete brain regions (Schreiber 2017). Since the emergence of fMRI studies, this research technique has proliferated into a vast array of scientific fields and applications, including political attitudes and behaviors.

Early functional imaging studies of political partisanship or ideology focused explicitly on neural responses to political stimuli. For example, Kaplan et al. (2007) analyzed how political party affiliation and corresponding attitudes modulated neural activity during the viewing of presidential candidates. By comparing neural activity to reported psychological responses, this study was able to conclude that viewing an opposing party candidate produced neural signals in the dorsolateral prefrontal cortex (DLPFC) and anterior cingulate cortex (ACC), regions known for their roles in cognitive control. Regions associated with emotional processing, like the insula and anterior temporal poles, were also implicated. Furthermore, neural activity was concordant with self-reporting feelings regarding the candidates; that is, the more negatively a subject felt about an opposing presidential candidate and the more positively they felt about their own, the greater the distinction in neural activity (Kaplan, Freedman, and Iacoboni 2007).

Moving away from overtly political tasks, Schreiber et al. (2013) explored differences between liberals and conservatives in a risk-taking task while undergoing fMRI. Based on psychological and physiological studies showing greater sensitivity and reactivity toward risk and conflict in conservatives, risk-taking tasks appropriately operationalize one's tendency to select action when uncertainty is present and adverse outcomes are possible. Indeed, results showed that while risk-taking behavior between the two groups did not differ significantly, brain activation did (Schreiber et al. 2013). In fact, a model of neural activity in two brain regions known to be involved in affective processing and subjective feeling states outperformed traditional models of parental socialization in predicting partisanship. These findings powerfully support the notion liberals and conservatives or Democrats and Republicans engage in distinct cognitive processes, and that these differences are reflected in biology.

Importantly, several fMRI studies have also examined the well-established negativity bias of the political right. In one functional imaging study, Pederson et al. (2018) examined neural activity with respect to both social and economic conservatism in response to threatening stimuli. Greater activity in threat-related neural circuitry (i.e., connectivity between the amygdala and BNST) was associated with economic, but not social conservativism (Pedersen, Tugan Muftuler, and Larson 2018). While studies had previously connected greater amygdala volume to conservatism, this was the first to show that conservatism was also directly linked to differences in amygdala function in the context of threat.

Ahn et al. (2014) similarly examined liberal/conservative differences in negativity bias, this time using a design paradigm aimed at assessing the effect of disgusting or threatening images on neural activity. These non-political images were hypothesized to predict political opinions due to the evolutionary role of disgust in defending against physical threats (Ahn et al. 2014). In other words, contemporary conservativism is associated with greater sensitivity toward disgust because this set of beliefs evolved from the ancient need to protect oneself against bodily threats. Consistent with expectations, results demonstrated that although conscious ratings of disgust did not differ between liberals and conservatives, brain responses to disgusting stimuli did, particularly those depicting so-called animal reminders. Neural activity during the viewing of a single disgusting image accurately predicted political ideology, emphasizing the importance of neural processing differences in political belief systems (Ahn et al. 2014).

Taken together, functional neuroimaging evidence suggests that liberals and conservatives or Democrats and Republicans differ neurobiologically in meaningful ways, particular in relation to negativity bias. Considering these findings, it is surprising that differences in emotion regulation capabilities have yet to be tested empirically. Emotion regulation offers one opportunity to reduce negativity bias, and assessing baseline differences in neural functionality during this task is a critical first step.

Emotion Regulation

Emotion regulation refers to a strategy intended to modulate the experiential, behavioral, or physiological systems activated due to an emotional cue (Gross and John 2003). Emotional responses form over time, and different emotion regulation strategies may be employed at any point during the emotion-generative process. One strategy of emotion regulation, reappraisal, is a cognitive process intended to transform one's emotional response to a stimulus, particularly a negative stimulus (Gross and John 2003). Prior to or during an emotional experience, cognitive reappraisal alters the emotional valence or salience of the negative stimuli to reinterpret its meaning. It is an explicit form of regulation aimed at adapting to negative experiences and is associate with improved health and mental well-being (Cutuli 2014). Emotional dysregulation, on the other hand, is a prevalent symptom in individuals suffering from anxiety or depression, and includes difficulty in managing negative emotions or negative biases (Fitzgerald et al. 2019).

Specific brain regions underlying emotional regulation in healthy populations have been established. Neural activity has been shown to increase across the dorsolateral prefrontal cortex (DLPFC), the ventrolateral prefrontal cortex (VLPFC), the dorsomedial prefrontal cortex (DMPFC), and the anterior cingulate cortex (ACC), among others (Buhle et al. 2014; Messina et al. 2015). Of particular importance are the dorsal anterior cingulate cortex (dACC) and the rostral anterior cingulate cortex (rACC). Overall, the ACC lies within the cortico-limbic system and serves important functions in cognitive and emotional networks (Fitzgerald et al. 2017). While the rACC is involved in implicit regulation and assessing the salience of stimuli (Gyurak, Gross, and Etkin 2011; Ochsner, Silvers, and Buhle 2012), the dorsal ACC (dACC) is implicated in conflict-monitoring processes and error detection (Gyurak, Gross, and Etkin 2011). Furthermore, both regions of the ACC have neural connections with the amygdala, which is a key anatomical structure in the producing emotional reactions to stimuli (Whalen 1998).

Successful emotion regulation is neuroanatomically demonstrated by an inverse relationship between ACC activity and amygdala activity (Banks et al. 2007; Ochsner, Silvers, and Buhle 2012). That is, as either dorsal or rostral ACC activity increases, amygdala activity will decrease. For example, in healthy individuals, activity in the dACC corresponds to a decrease in amygdala activity during reappraisal (Messina et al. 2015), but in individuals with emotional dysregulation, there is a delayed engagement of the dACC when reappraising negative stimuli (Goldin et al. 2009). Similarly, the rACC is used to manage competing streams of information, and effective regulation engages the rACC in implicit regulation and reduces amygdala activity (Gyurak, Gross, and Etkin 2011). Deficient rACC activity has been linked to attentional bias to salient distractors (Gyurak, Gross, and Etkin 2011). Thus, a functional relationship exists between frontoparietal structures and the amygdala during cognitive reappraisal.

At least one study has examined political ideology and neurocognitive processes of self-regulation (Amodio et al. 2007), though not in the context of neuroimaging. By analyzing event related potentials (ERPs) during a Go/No-Go task, this study specifically addressed individual differences in response inhibition. The ACC was again implicated in self-regulation, as liberals showed significantly greater neural activity in the ACC when response inhibition was required.

This study lays the groundwork for a functional examination of emotion regulation, and there is reason to believe liberals/Democrats and conservatives/Republicans will demonstrate significant differences in neurobiological mechanisms.

To examine functional neural activity during emotion regulation, one dominant paradigm is the Emotion Regulation Task (ERT), which focuses on the down-regulation of negative affect through cognitive reappraisal (Klumpp et al. 2017; Parvaz et al. 2012). During this task, participants are instructed to either “look” or “reappraise” negative images from the International Affective Picture System (IAPS). Participants are trained to “reappraise” negative images by imagining less negative scenarios surrounding the image before the task. For example, an image of red liquid substance on a person’s hands may initially be understood to be blood, but could be reappraised to be paint or another, less negative, context. When asked to “look” at the images, participants passively look at the picture without any attempt to decrease negative affect. Comparisons can be made between the Look-Neutral and Look-Negative blocks, as well as between the Reappraise and Look-Negative blocks.

H1: Conservatives will be more impaired by negative information than liberals in an emotion regulation neuroimaging task.

H2: Republicans will be more impaired by negative information than Democrats in an emotion regulation neuroimaging task.

Methods

Sample

The sample was derived from patients who were admitted to, or had an injury-related visit to, a midwestern Level 1 Trauma Center. Potential subjects were provided with study details and asked to participate either in-person or after discharge with a phone call. Consent to participate was obtained during visit one, and participants completed a series of questionnaires and had blood drawn (5mL). Questionnaires included: PCL-5, ETV-C, PEDQ, psychiatric history, substance abuse, CTQ, CESD, DERS-SF, DSI-SS, SBQ-R, MTOP COVID-19 Inventory, the MTOP Demographics Inventory, and the LEC. The Injured Trauma Survivor Screen (ITSS) was utilized to measure the risk of developing post-traumatic stress disorder (PTSD) and depression one-month post injury (Hunt et al. 2021). Only patients who were risk positive (i.e., a score of 2 or more on the ITSS) were recruited to participate past the visit one questionnaires.

Procedure

Approximately 100 participants screened risk-positive on the ITSS, and goal of 50 participants was set for the neuroimaging protocol. Subjects were asked to participate in the neuroimaging protocol if they scored either very high on the PTSD diagnostic tool the PCL-5 (PCL-5>30), or very low on the PCL-5 (PCL-5<10). A separate visit was scheduled two to four weeks after the date of trauma for the MRI scans.

For eligible and consenting participants, the MRI scans took approximately one hour, and participants were compensated with $100. After a resting state scan, two emotion tasks were conducted. The Emotion Regulation Task (ERT) was completed first. This task consisted of two runs, lasting 13 minutes in total. Each block consisted of 4 images, either negative (32 images total) or neutral (16 images total). During each block, participants viewed each image for 5 seconds, with a total block time of 20 seconds. Participants were instructed to either "look" or "reappraise" prior to each block, and after a cognitive reappraisal training session.

Before half of the negative images, participants were asked to "look," while the rest of the images were preceded by instructions to "reappraise." Participants were asked to "look" before all neutral blocks. After each block, participants were asked to rate their feelings of negativity on a 5-item Likert scale with 5 being most negative. There was a 20-second rest period between blocks, and participants were able to relax while focusing on a white fixation on a black screen. In total, 4 negative blocks and 2 neutral blocks were presented for each run, and block order was pseudo-randomized for each participant.

Survey Measures

During visit one, participants self-reported their political affiliation and political ideology. For party affiliation, participants could select either a strong Republican, a weak Republican, neither a Republican nor a Democrat, a weak Democrat, or a weak Republican. For ideological orientation, participants could select strongly conservative, weakly conservative, neither conservative nor liberal, weakly liberal, or strongly liberal.

Basic demographic and injury-related characteristics were also collected, including sex at birth, race, ethnicity, mechanism of injury, and injury severity score. Additional measures were included to quantify the severity or impact of the exposure to trauma on the sample, including the Injured Trauma Survivor Screen, the PTSD Checklist for DSM-5 (PCL-5), and the Clinician-Administered PTSD Scale for DSM-5 (CAPS -5), which is the gold standard instrument for assessing posttraumatic stress disorder.

Data Acquisition

Images were obtained on a GE Signa Premier 3T scanner with high-speed gradients and a 48-channel head coil (General Electric Healthcare, Waukesha, WI). A gradient-echo echo-planar imaging sequence was utilized. A T1-weighted, high resolution volumetric anatomical scan was also conducted for anatomical localization.

Preprocessing was conducted in Matlab (v.2019) and SPM (v.12) and consisted of standard corrections, including dropping the first 2 volumes to reach optimal MRI signal, slice timing realignment to adjust for the time taken to scan the brain from front to back or top to bottom, normalization in to a MNI common space with skull-stripping, and spatial smoothing using a 5mm FWHM kernel. First-level analyses were also conducted to pair the stimulus schedule with the data, which is then convolved with the canonical hemodynamic response. A 128 s high pass filter was also utilized and nuisance regressors were added to correct for motion artifacts. The Emotion Regulation Task consisted of two contrasts of interests, one in which activation during the “look-neutral” condition and the “look-negative” condition was compared (*i.e.*, the maintain contrast), and one in which activation during the “look-negative” condition and the “reappraise” condition was compared (*i.e.*, the reappraise contrast).

Analysis

Using Wilkes-Shapiro tests, the distributions of ideology and partisanship were determined to be non-parametric. Therefore, the relationship between continuous variables and ideology or partisanship were evaluated with Spearman correlation coefficients and tests, while categorical variables were assessed with Wilcox rank sum tests or Kruskal Wallis tests, as appropriate. All statistical analyses were conducted in R Statistical Software (v1.2.5042; R Core Team 2021).

Structural neuroimaging analyses were conducted after brain region volumes were derived from Freesurfer (v.7.2.0) using the recon-all command for automated tissue segmentation and parcellation. General linear models were utilized to determine whether region of interest volumes were associated with either ideological or partisan orientation.

For functional analyses, the preprocessed first-level neuroimaging data was subjected to second-level, or group-level, analyses using SPM (v.8). One-sample t-tests were used to investigate the relationship between political ideology and political partisanship and neural activity separately, each on a 5-point Likert. Two contrasts were analyzed for each political grouping, the maintain contrast, and the reappraise contrast. Uncorrected p-values of $p<0.001$ were used with a cluster-defining threshold for a false positive rate of 0.05.

Results

A total of 33 subjects had usable functional imaging data for the Emotion Regulation Task. Responses for political ideology and partisanship were treated as continuous variables, with higher numbers being equivalent to conservatism or the Republican party. Table 11 describes the sample statistics. The majority of respondents reported that they self-identified as neither liberal nor conservative (n=18), with 4 indicating they were somewhat liberal, and 3 indicating they were somewhat conservative. A total of 7 respondents identified as very liberal, and only 1 respondent reported they were very conservative. Partisanship was similar, with most respondents indicating they were neither Democratic nor Republican (n=23). There were 2 respondents in each of the weakly Republican and weakly Democratic groups. Lastly, there were 5 strong Democrats, and only 1 strong Republican.

Table 11. Sample Characteristics

Characteristic	**N = 33**[1]
Age	29.00 (25.00, 39.00)
Sex	
Female	16 (48%)
Male	17 (52%)
Race	
2+	4 (12%)
AI or Alaskan	1 (3.0%)
Black	20 (61%)
White	8 (24%)
Hispanic/Latino	
Hispanic/Latino	2 (6.7%)
Not Hispanic/Latino	28 (93%)
Unknown	3

Characteristic	N = 33[1]
Injury Severity Score	8.00 (5.00, 11.50)
Unknown	29
Mechanism of Injury	
DV/Assault	3 (9.1%)
Fall	2 (6.1%)
MVC/Struck/Motorcyle	25 (76%)
Other	2 (6.1%)
Stab	1 (3.0%)
ITSS Total	7.00 (5.00, 8.00)
PCL-5 Total Score	51.00 (39.00, 60.00)
CAPS-5 Total Score	16.00 (7.50, 22.75)
Unknown	7
CAPS-5 PTSD Diagnosis	9 (35%)
Unknown	7
Political Ideology	
1	7 (21%)
2	4 (12%)
3	18 (55%)
4	3 (9.1%)
5	1 (3.0%)
Political Partisanship	
1	5 (15%)
2	2 (6.1%)
3	23 (70%)

Characteristic	N = 33[1]
4	2 (6.1%)
5	1 (3.0%)

[1] Median (IQR); n (%)

As shown in Table 12, political ideology was positively but weakly correlated with age (r=0.16), and negatively but weakly correlated with baseline PCL scores (r=-0.18) and CAPS5 total severity (r=-01.16) scores. ISS was excluded due to missingness. None of these correlations met the criteria for statistical significance. Table 13 reports median political ideology scores by sample characteristics. Political ideology was significantly associated with sex at birth (p<0.001), with both males and females having a median ideology score of 3, but males skewing higher in interquartile range (2-3 vs. 1.75-3). Race was also significantly related to political ideology, with white respondents having a lower median ideology score (2) than black, American Indian/Alaskan, or multi-race respondents (3, p=0.036), as was ethnicity (p<0.001). Finally, respondents who had a CAPS-5 diagnosis of posttraumatic stress disorder at 6 months post-injury had statistically lower median ideology scores (2, 1-3) than those who did not (3, 3-3, p<0.001).

Table 12. Spearman Correlations

	Political Ideology	Political Partisanship
Age	0.16 p=0.295	-0.03 p=0.594
ITSS	0.05 p=0.993	0.03 p=0.942

PCL-5 Total	-0.18 p=0.405	-0.16 p=0.459
CAPS-5 Total	-0.16 p=0.447	-0.40 p=0.018

Table 13. Median Political Ideology by Sample Characteristics

Political Ideology	Median (Q1-Q3)	p-value
Sex		<0.001
Male	3 (2-3)	
Female	3 (1.75-3)	
Race		0.036
2+	3 (2.5-3)	
AI/Alaskan	3 (3-3)	
Black	3 (2.75-3)	
White	2 (1.75-3.25)	
Ethnicity		<0.001
Not Hispanic/Latino	3 (2-3)	
Hispanic/Latino	2.5 (1.75-3.25)	
Mechanism of Injury		0.308
DV/Assault	3 (3-3)	
Fall	3 (3-3)	
MVC/Struck/Motorcycle	3 (2-3)	
Other	2.5 (1.75-3.25)	
Stab	3 (3-3)	
CAPS-5 Diagnosis		<0.001
No	3 (3-3)	
Yes	2 (1-3)	

Political party affiliation was negatively correlated with age (r=-0.03) baseline PCL-5 scores (r=-0.16) and CAPS-5 total severity scores (r=-0.40). Only the correlation between party affiliation scores and the CAPS-5 severity reached statistical significance (p=0.018), indicating that as respondents became more Republican politically, their CAPS-5 scores were lower. Still, a correlation coefficient of 0.4 borders between a weak and moderate effect size. Table 14 reports median political partisanship scores by sample characteristics. Sex at birth was significantly associated with partisanship (p<0.001), as was ethnicity (p<0.001). Race and mechanism of injury were not statistically different in partisanship (p=0.288 and p=0.313, respectively). As with political ideology, diagnosis of posttraumatic stress disorder through the CAPS-5 interview at 6 months was statistically associated with partisan affiliation (p<0.001).

Table 14. Median Political Partisanship by Sample Characteristics

Political Partisanship	Median (Q1-Q3)	p-value
Sex		<0.001
Male	3 (3-3)	
Female	3 (3-3)	
Race		0.288
2+	3 (2.75-3)	
AI/Alaskan	3 (3-3)	
Black	3 (3-3)	
White	3 (2.75-3.25)	
Ethnicity		<0.001
Not Hispanic/Latino	3 (3-3)	
Hispanic/Latino	2.5 (1.75-3.25)	
Mechanism of Injury		0.313
DV/Assault	3 (3-3)	
Fall	3 (3-3)	
MVC/Struck/Motorcycle	3 (2-3)	
Other	2.5 (1.75-3.25)	
Stab	3 (3-3)	
CAPS-5 Diagnosis		<0.001
No	3 (3-3)	
Yes	3 (3-3)	

Analyses of structural neuroimaging results were undertaken next. Models were run for political ideology and partisanship separately. Bilateral Regions of Interest (ROIs) consisted of the amygdala, anterior cingulate cortex, insula, and entorhinal cortex based on prior studies (Ryota Kanai, Feilden, et al. 2011). Whole brain volume was included as a potential confounder and was calculated as the sum of total cerebral white matter and total gray matter. Other covariates and adjustments for multiple comparisons were not incorporated in the reported models.

Table 15 displays the results from structural brain imaging volume models for political ideology. Results demonstrate that none of the predefined neural regions were statistically associated with ideological orientation. Table 16 reports the same statistics for the relationship between ACC, amygdala, entorhinal cortex, and insula volumes and political partisanship. Once again, no statistically significant correlations were found.

Table 15. Linear Regressions of Political Ideology

Characteristic	**Beta**	**95% CI**[1]	**p-value**
Left ACC	-0.000	0.00, 0.00	0.436
Right ACC	0.000	0.00, 0.00	0.446
Total Brain Volume	0.000	0.00, 0.00	0.230
Characteristic	**Beta**	**95% CI**[1]	**p-value**
Left Amygdala	0.001	0.00, 0.00	0.439
Right Amygdala	-0.002	0.00, 0.01	0.147
Total Brain Volume	0.000	0.00, 0.00	0.131
Characteristic	**Beta**	**95% CI**[1]	**p-value**

Characteristic	Beta	95% CI[1]	p-value
Left Entorhinal	-0.000	0.00, 0.00	0.774
Right Entorhinal	0.001	0.00, 0.00	0.140
Total Brain Volume	0.000	0.00, 0.00	0.487

Characteristic	Beta	95% CI[1]	p-value
Left Insula	-0.000	0.00, 0.00	0.356
Right Insula	0.000	0.00, 0.00	0.734
Total Brain Volume	0.000	0.00, 0.00	0.214

[1] OR = Odds Ratio, CI = Confidence Interval

Table 16. Linear Regressions of Political Partisanship

Characteristic	Beta	95% CI[1]	p-value
Left ACC	-0.000	0.00, 0.00	0.103
Right ACC	0.000	0.00, 0.00	0.545
Total Brain Volume	-0.000	0.00, 0.00	0.690

Characteristic	Beta	95% CI[1]	p-value
Left Amygdala	-0.002	0.00, 0.00	0.158
Right Amygdala	0.001	0.00, 0.00	0.356
Total Brain Volume	-0.000	0.00, 0.00	0.496

Characteristic	Beta	95% CI[1]	p-value
Left Entorhinal	0.000	0.00, 0.00	0.492
Right Entorhinal	-0.001	0.00, 0.00	0.073
Total Brain Volume	-0.000	0.00, 0.00	0.509

Characteristic	Beta	95% CI[1]	p-value
Left Insula	0.000	0.00, 0.00	0.967

Characteristic	Beta	95% CI[1]	p-value
Right Insula	0.000	0.00, 0.00	0.216
Total Brain Volume	-0.000	0.00, 0.00	0.091

[1] OR = Odds Ratio, CI = Confidence Interval

Whole brain functional neuroimaging data from the Emotion Regulation Task was subsequently analyzed. Neural activity was examined with respect to both political ideology and partisanship, for the maintain and the reappraise conditions separately. Hemodynamic responses were contrasted between the look-neutral and the look-negative conditions for the maintain contrast, while hemodynamic responses were contrasted between the look-negative and the reappraise conditions for the reappraise contrast. Voxels meeting the $p<0.001$ peak-level threshold were analyzed, with a Family-Wise Error rate correction of $p<0.05$.

The first analysis examined the relationship between ideological orientation and the maintain and reappraise contrasts. There were no statistically significant associations between ideology and either condition when adjusting for multiple comparisons. For the maintain condition, uncorrected p-values under 0.001 had a maximum peak-level t value of 4.52 (FWE $p=0.974$) for a positive association between ideology and activity, and a t value of 4.46 (FWE $p=0.985$) for a negative association between ideology and activity. Similarly, for the reappraise condition, uncorrected p-values under 0.001 had a maximum peak-level t value of 4.88 (FWE $p=0.862$) for a positive association and a t value of 5.31 (FWE $p=0.518$) for a negative association. Therefore, ideology within this sample did not correlate with differences in neural activity during the maintain or reappraise contrasts.

The relationship between partisanship and neural activity during the maintain condition mirrored that of ideology. Neither the positive relationship (t=3.67, FWE p=0.985) nor the negative relationship (t=6.02, FWE p=0.072) met the criteria for statistical significance with FWE correction. The negative contrast for the reappraise condition also failed to reach statistical significance in area regions (t=4.43, FWE p=0.996), but there was a positive relationship between partisanship and neural activity in one region with a 50-voxel cluster (MNI coordinates x=54, y=-60, z=18) during the reappraise condition (t=6.91, FWE p=0.006). This cluster maintained statistical significance when including covariates of subjects' sex and age (t=6.90, FWE p=0.009). Voxels in this region generally correspond to the right inferior parietal lobule (IPL) according to the Human Brainnetome Atlas (Fan et al. 2016). Figure 3 depicts the region of statistical significance within the crosshairs, shown in sagittal, coronal, and axial views.

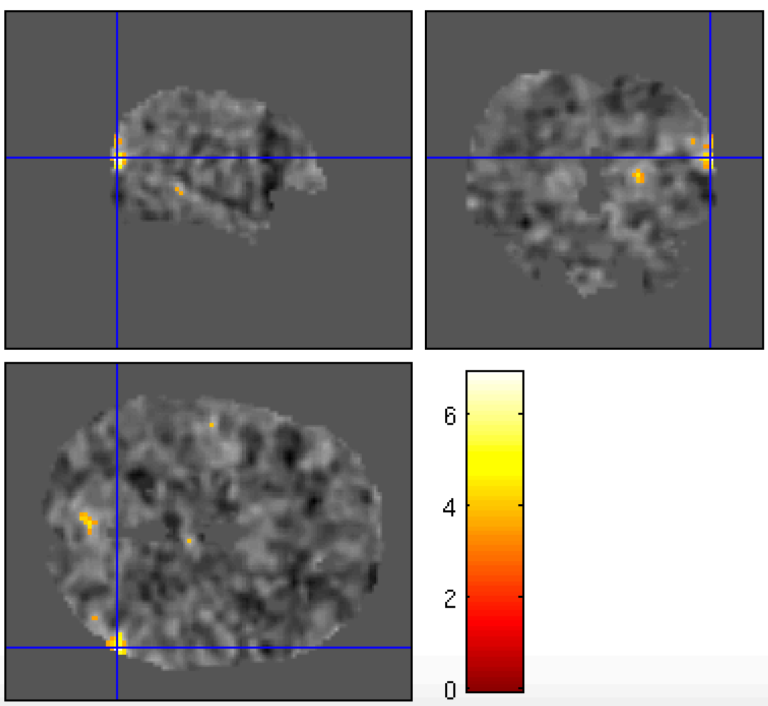

Figure 3. Significant Voxels for Partisanship and Reappraisal.

Discussion and Conclusions

Contrary to expectations, liberals and conservatives and Democrats and Republicans did not significantly differ in neuroanatomical structure volume, nor did they differ in most conditions of functional neural activity in the Emotion Regulation Task. Across the ideological spectrum, there were no significant differences while viewing negative images compared to neutral ones, and there were no significant differences while reappraising a negative image when compared to viewing a negative image. There was, however, a significant positive relationship between partisanship and neural activity in the right inferior parietal lobule during the reappraise condition. That is, the difference in neural activity between viewing a negative image and reappraising it was positively associated with being a member of the Republican party.

Like most regions, the IPL is multifaceted and has wide ranging neural interconnectivity. Figure 4 depicts the anatomy of the right IPL. Most often, the IPL is associated with its functional processing of sensory and sensorimotor information. These operations include spatial attention, sensory integration, and oculomotor control (Clower et al. 2001). The right IPL in particular has been shown to be involved with maintaining attentive control on current task goals and reacting to salient novel stimuli (Singh-Curry and Husain 2009). As such, lesions within the right IPL are associated with deficits in attention and responding to new information, as well as motor impairments and unilateral spatial neglect.

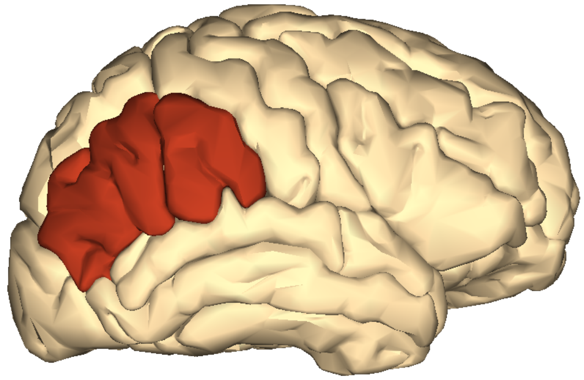

Figure 4. Anatomy of the right inferior parietal lobule (Anatomography, 2012).

The role of the IPL in maintaining attention when attempting to reappraise a negative image is conceptually consistent with the hypothesis that Republicans (or conservatives) have greater attention toward negative stimuli than Democrats (liberals). Despite a lack of difference in regions typically associated with emotion regulation (*e.g.*, the ACC or amygdala), maintaining attention on the negative image during the reappraisal condition would be anticipated for Republicans, and may therefore be reflected in increased IPL activity. More research is needed to confirm these findings, but a positive association between Republicanism and the maintenance of attention during the reappraisal of a negative image coincides with theories of a negativity bias.

The in consistent findings between ideological and partisan orientation was not anticipated. It may indicate a sincere difference in the neural underpinnings of political ideology compared to political partisanship, or it may be an artifact of an imbalanced sample. For both ideology and partisanship, the vast majority of subjects fell into the neither category. Only 4 subjects self-identified as ideologically conservative in any respect, and only 3 indicated they were Republicans. This lack of variation and skew away from conservatism/Republicanism is a limitation of this study; however, it is not uncommon for conservatism to be underrepresented in neuroimaging studies. For example, none of the 90 participants in Kanai et al.'s (2011) structural imaging study identified as "very conservative," and none of the 24 participants in a study investigating the connection between conservatism and the neural circuitry of threat identified as "very conservative" (Pedersen et al. 2018).

It is also not possible to exclude the effects of exposure to trauma from this sample. Measures of posttraumatic stress disorder, including the CAPS-5 severity score and CAPS-5 PTSD diagnosis, were significantly associated with political ideology or partisanship. With this in mind, differences in neural activity during emotion regulation may be attributable to true neurobiological distinctions across the political spectrum, or they may be products of distinct reactions to trauma. In other words, if liberals/Democrats are more susceptible to the influences of trauma on the brain than conservatives/Republicans, post-trauma neural differences may depict the effects of trauma more than political affiliation. An interactive effect between ideology/partisanship and trauma cannot be discounted.

Given these limitations, it is important that these studies continue to be replicated in large, diverse, and politically representative samples. That structural correlations with ideology and partisanship could not be replicated in this study suggests that the field of biopolitics would benefit greatly from additional neuroimaging analyses, and conclusions cannot be reliably drawn until findings are consistent and stable across samples. Future research should also examine differences in neural activity during emotion regulation in non-trauma exposed participants to determine if the right IPL is indeed integrated differentially across political groupings. The most conspicuous takeaway from this set of studies is that more work is needed in biopolitics, but the potential contribution to political science is undoubtedly worth the effort.

Chapter Five: Conclusions

An Evolutionary Approach

Through the lens of evolutionary biology, modern political cognition, affect, and behavior originate from brain regions evolved for other, ancient purposes. Contrary to early conceptualizations, the brain is not a *tabula rasa*; it is a collection of neural circuitries that are functionally specialized and domain-specific (Tooby and Cosmides 1995). These circuits influence our perceptions, experiences, motivations, and frames of meaning. Evolutionary biology has demonstrated that our brains are physical systems, dictated by chemical reactions and neuronal activity, designed by natural selection to solve the problems of our ancestors (Tooby and Cosmides 1995). Natural selection has created these complex, organized machines over time in a manner which provided adaptive advantages, such that different neural circuits are specialized for solving distinct, stone-age problems (Cosmides, Tooby, and Kurzban 2003; Tooby and Cosmides 1995). Simply put, our modern brains are the contemporary culmination of the neurobiological adaptations of our hunter-gatherer ancestors. Early human needs like cooperation and group conformity have created functionally specific regions of our brains which ultimately correspond to modern political phenomena, including ideology and partisanship (Claessens et al. n.d.). In this way, understanding the human brain will inevitably lead to a greater understanding of political affiliations and orientations.

In this dissertation, I have argued in favor of a multidisciplinary, evolutionary-based approach to the study of political ideology and partisanship, specifically one in which the biological basis of humanity is acknowledged and respected. In an attempt to unify the siloed areas of research in evolutionary biology and political science, I called upon neuroimaging tools to provide a more nuanced and accurate depiction of our political brains. Neuroimaging techniques, both structural and functional varieties, have experienced a tremendous period of growth and development in recent decades, and these methods have been integrated into almost all field of social sciences, including political science. Despite the initial successes of such research endeavors, political science has nearly abandoned neuropolitical approaches, instead relying on parochial theories of behaviorism and rational choice.

Missing from these traditional theories of political science is an examination of the root causes of human cognition, affect, and behavior. Neuropolitics opens the “black box” of political attitudes and behavior, focusing on the foundations of such phenomena rather than the outputs. Incorporating knowledge from neuropolitics and gaining a deeper understanding of the brain in political contexts does not negate advances made through classical methods; instead, neuropolitics should supplement extant information to create all-encompassing theories of political attitudes and behavior.

The studies presented within this dissertation have focused explicitly on applying neuroimaging techniques to questions surrounding the biological correlates of political ideology and partisanship. In particular, I sought to determine whether strong political ideologues or partisans were neurobiologically distinct from weak ideologues/partisans. I also reexamined differences between political orientations on ideological or partisan spectrums using a both structural analyses and a functional task not yet analyzed with respect to political groupings. I found evidence that political ideology and partisanship does in fact have neurobiological correlates, though the ability to draw robust conclusions is somewhat limited by sample characteristics.

Hypotheses and Results

Hypotheses within this dissertation were derived from a hierarchy of theoretical foundations. First, the evolutionary theory of biology provides the basis for examining biological components of modern-day political phenomenon (Cosmides, Tooby, and Kurzban 2003; Tooby and Cosmides 1995). Next, social identity theory helps to explain why social group attachments are psychologically-driven, powerfully influential on our attitudes and behavior, and ubiquitously present in human nature (H. Tajfel and Turner 1979; Henri Tajfel 1970). Situated within the broader context of social identity theory, the uncertainty-identity theory further states that people identify more strongly with a given social group to reduce uncertainty, particularly during times of fear or threat (M. A. Hogg, Meehan, and Farquharson 2010; Michael A Hogg and Adelman 2013). Lastly, the extremism hypothesis offered by van Prooijen et al. (2015; van Prooijen and Krouwel 2017, 2019) overtly ties group attachments to the political realm. According to the extremism hypothesis, political extremes at either end of the political spectrum display characteristics typically ascribed to the political right (*e.g.*, the "rigidity of the right"). There is an enhanced desire to reduce fear and uncertainty among extremes of both ideological orientations and partisan affiliations, and it is this shared psychological motivation that connects strong identifiers, regardless of which direction they lean.

In Chapter 2, neuroimaging structural analyses were undertaken to determine if brain regions of interest differed significantly in volume when comparing strong and weak political ideologues and partisans. Based on prior structural analyses comparing liberals and conservatives, and in conjunction with evidence from studies of the extremism hypothesis, it was hypothesized that strong political affiliates (*e.g.*, "extremists") would present with greater gray matter volume in the amygdala, left insula, and right entorhinal cortex, as well as less gray matter volume in the anterior cingulate cortex. No significant differences in brain volume were found when comparing strong and weak partisans, but the left insula was negatively and significantly associated ideological extremism. These findings were replicated using an ideological scoring system, in which subjects with strong, weak, and no ideological orientation were represented.

While a significant difference in insular volume was detected, the association with ideology ran in the opposite direction as expected. Greater volume in the left insula is most commonly attributed to conservatism due to its role in processing disgust; it was therefore anticipated to coincide with more extreme political affiliations as well. This contradictory finding may serve to refute portions of the extremism hypothesis, or it may simply reflect the myriad other functional processes attributed to the insula. In fact, the left insula's role in cognitive or emotional functioning may be negatively correlated with strength of political attachment, while its role in disgust is positively associated with conservatism.

Chapter 3 examined differences between strong and weak political attachments in the context of functional neuroimaging. During an Emotion Regulation Task, neural activity was recorded in subjects while they viewed a neutral picture or negative picture, and while they "reappraised" a negative image. It was hypothesized that strong liberals/Democrats and strong conservatives/Republicans would both be more attentive to negative stimuli than political moderates. While political moderates were expected to show neural activity in areas classically associated with successful emotion regulation, extremists would not. In the maintain contrast, neural activity was contrasted between looking at a neutral image and looking a negative image. In the reappraise contrast, neural activity was contrasted between looking at a negative image and reappraising the negative image with a more positive meaning. Findings suggest that strength of political attachment was not related to neural activity during either contrast of this task, either as a dichotomous or a continuous variable.

Again, this lack of significant findings may indicate that the extremism hypothesis is not an accurate depiction of strong political identifiers. Instead, the differences between liberals/Democrats and conservatives/Republicans may supersede any shared psychological motivations of political extremists. On the other hand, these null results may be solely the result of an unbalanced, trauma-exposed sample, or an emotion regulation paradigm that does not accurately characterize the shared neural activity of political moderates and extremists.

Finally, in Chapter 4, both structural and functional neuroimaging analyses were conducted looking at traditional differences between liberals/Democrats and conservatives/Republicans. The structural analysis was intended to replicate prior findings in an additional sample, while the functional analysis was aimed at expanding our knowledge of the differences in neural activity between political orientations. None of the hypothesized structural differences were noted, and only one portion of the functional analyses showed any statistical significance. Namely, neural activity was correlated with political partisanship in the reappraise condition of the emotion regulation task. This activity only maintained statistical significance in the inferior parietal lobule, a region of the brain known for its roles in sensory and sensorimotor processes. Importantly, this region is also implicated in the maintenance of attention, which supports extant evidence that Republicans have a greater selective attention toward negative images than Democrats. Still, the sample distribution and lack of consistency with ideological groups caution against overinterpreting results.

Limitations

Results of these studies cannot be properly understood without a thorough discussion of the limitations, and how such limitations may exert influence on statistical approaches. Perhaps the most glaring limitation is the sample itself. Standards for sample size for neuroimaging studies have evolved in recent years, with a novel understanding of parameters necessary to draw reproducible conclusions. It is generally accepted that most fMRI studies to date suffer from limited statistical power due to small sample size, and studies of sample size have found highly variable results depending on the analytic method and brain measure assessed (Grady et al. 2021). Increasing sample size is consistently found to be associated with improved stability and less spurious correlations, while the disadvantages of small sample sizes are many.

Low powered studies have serious problems in addition to an inability to detect true effects. For example, low power increases the false report probability, increases sampling variability and noisy measurements, and increases effect sizes, even when effect sizes are small (Szucs and Ioannidis 2020). Formal power calculations for fMRI studies are exceedingly rare and are usually computed for single runs of t-tests, not adjusted for the more stringent p-value of fMRI designs. Using the $p<0.001$ standard of fMRI studies, detecting a moderate effect size (0.5) with just 80% power would require a minimum single group sample size of 74. For a smaller effect size (0.3), 196 participants would be necessary (Szucs and Ioannidis 2020). In fMRI specific power calculations, replicability requires sample sizes above 100 subjects (Szucs and Ioannidis 2020).

Clearly, this sample size does not meet the optimal standards for MRI analyses. Even more problematic, the sample is imbalanced in terms of political ideology and partisanship. In each measure, over half of the sample identified as neither liberal nor conservative (55%) or neither Democrat nor Republican (70%). Only 8 and 6 subjects identified as strongly ideological or strongly partisan respectively, and very few subjects identified as conservative/Republican in any capacity. While appropriate statistical methods were applied to account for small cell sizes in bivariate analyses, the nature of the distribution of this sample increases the likelihood that neuroimaging results could have been biased or skewed by unrepresentative data. Outliers may exert undue influence or leverage on the overall results, challenging the validity of interpretations.

To add to the complexity of interpreting the results of the dataset, it is essential to also consider the possible influence of exposure to trauma on neuroanatomy and function. Studies of posttraumatic stress disorder have shown changes in the neural circuitry around threat and stress after traumatic exposure, particularly in the amygdala and medial prefrontal cortex (Patel et al. 2012). In the event that exposure to trauma and the development of trauma-related disorders affect subjects equally, regardless of strength or direction of political attachments, results of this study can still be interpreted as depicting true differences between strong and weak political groups or liberals/Democrats and conservatives/Republicans. However, it is possible that the effects of trauma interact with preexisting ideological or partisan leanings, such that the neural circuitry of certain political groups is altered more, or in a different way, than other groups. In this case, neuroimaging differences between strong and weak partisans, for example, may represent the influence of trauma to a greater extent than the influence of strength of partisanship. Available measures of the psychological effects of exposure to trauma were evaluated for differences between political groups, but an interactive effect still cannot be discounted.

In addition to the limitations specific to this study sample, other factors generalizable to all neuroimaging studies should also be considered. For example, fMRI studies require the acceptance of certain assumptions, since brain activity cannot be measured directly. Functional imaging instead measures the oxygen content of blood in the brain, which is assumed to correlated with neural activity. It is assumed that because the brain requires oxygen to activate, the change in BOLD signals depicts neural activity. Although some of these assumptions are beginning to be tested explicitly, and with reassuring conclusions (Arbuckle et al. 2019), the field of neuroimaging overall is still fine-tuning detailed aspects of the process to produce more consistent results (Renvall, Nangini, and Hari 2014).

The connection between neuroanatomy and attitudes or behavior is in a similar state of scientific growth. In early research, neuroanatomy was linked to function by examining the consequences of damage (e.g., Phineas Gage), or differences between the human brain and other mammalian brains (Genon, Eickhoff, and Kharabian 2022). However, the connection between individual variability in brain structure and attitudes or behavior is complex, as neural regions are multifaceted and a one-to-one mapping of structure and function in healthy populations is still elusive (Genon, Eickhoff, and Kharabian 2022). The reciprocal relationship between structure and function further complicates matters; the structure of the human brain both shapes and is shaped by its function and the surrounding environment (Maguire et al. 2000). It is not possible, for example, to conclude that ideology or partisanship is *caused by* a particular neuroanatomical region. Political group attachments are, at best, correlated with neuroanatomy or function.

Original Knowledge and Contributions

Despite the aforementioned limitations, the studies presented here offer original knowledge and significant contributions for the field of political science. First and foremost, the continued use of interdisciplinary theories and methods within political science enhances both the accuracy and credibility of models of political attitudes and behavior. In lay terms, Pandora's box has already been opened with extant studies using biopolitical approaches. To ignore these initial attempts at applying neurobiological techniques to political science is shortsighted, and only prolongs the inevitable acknowledgement that the brain is an essential component all human phenomena. As other fields of social science research embrace the use of neuroimaging, political science will fall behind in its adherence to parochial theories that do not explain political behavior fully, or accurately. In this broad sense, this dissertation is an attempt to reinvigorate biopolitics research and encourage the integration of advanced biological methods into the study of any aspect of human behavior.

More specifically, these studies are the first to examine the neurobiological foundations of *strength* of political attachment. Moving beyond the directionality of political affiliations, the study of strength of political attachment is increasingly critical in a politically and affectively polarized environment. Without a strong political attachment to an ideological or partisan group, polarization among everyday Americans would not occur. Few areas of research within political science influence the daily lives of Americans to the same degree as affective polarization, as relationships with families, friends, and neighbors have become progressively more contentious. In fact, polling has revealed that approximately 80% of partisan Americans feel "very unfavorably" toward individuals belonging to the opposing political party (Pew Research Center 2017) and perhaps unsurprisingly, around one-third of Americans believe that the use of political violence may be justified (Kornfield and Alfaro n.d.).

Research shows that the relationship between polarization and political violence has strengthened, and that the incidence of politically related threats of violence and acts of violence have also increased (Kleinfeld 2021; Trump et al. 2020). Studies have demonstrated that highly polarized Americans are more likely to exclude, discriminate, and punish members of the opposing political party (Iyengar and Westwood 2015; Westwood et al. 2018). In one of the few studies to explicitly investigate the association between political polarization and political violence, results confirm that polarization does influence individual support for political violence (Piazza 2021). Namely, polarized Democrats are 8% more likely to support political violence, while polarized Republicans are 18% more likely to endorse political violence as a tool. Globally, democracies with high levels of partisan polarization are 34% more likely to experience frequent non-state political violence, adjusting for regime type, electoral system, ethnolinguistic and socioeconomic division, economic development, or history of political violence (Piazza 2021).

The nexus between polarization and political violence is perhaps the prominent reason to devote time and resources to the development of a comprehensive model of political polarization in the United States. While traditional studies may explore the social, economic, or political causes of polarization, examining the biological mechanisms of this ongoing trend offers a more thorough understanding of why some individuals become polarized, and others do not. Indeed, this dissertation provides novel insights into neurobiological differences between those who identify strongly with an ideology or party, and those who do not. In this sample, strong political ideologues presented with less gray matter volume in the left insula when compared to ideological moderates. Not only could this finding help to explain one's proclivity toward strong political attachments or predict who may be most likely to become polarized, but it may also help target interventions to reduce the negative consequences typically ascribed to polarization.

By isolating which neural structures and mechanisms are associated with strong political attachments, biology offers guidance into the most effective areas in which to intervene. As an example, the field of neuropsychology applied knowledge of the neurobiology involved in anxiety disorders to develop cognitive behavioral therapy treatments. This cognitive behavioral approach was shown to significantly alter the neural circuitry recruited in the regulation of negative emotions and fear extinction (Ribeiro Porto et al. 2009). While the potential for psychological treatment to modify neural circuitry involved in the development or maintenance of strong political attachments is purely theoretical at this stage, it is worth considering that these techniques have worked with arguably more complex mental disorders.

Along similar lines, knowing that Republicans show more neural activation in the right inferior parietal lobe during the reappraisal of a negative image may suggest targeted communication strategies. Understanding the basis for Republicans' maintenance of attention on negative stimuli can aid in the communication of political or personal information, which may be beneficial to the governing process or interpersonal relationships. Tactics that work against this group's natural focus on threat or uncertainty are unlikely to efficiently convey messages, whereas strategies that are sensitive to these inherent neural differences are more likely to be successful. Of utmost importance, this technology is not intended to manipulate, coerce, or force any individual into changing their political orientations or psychological profiles. The goal of neurobiological approaches to the study of political attachments and polarization is to improve government function, interpersonal relationships, and reduce political violence.

In addition to the specific neurobiological insight gained from the studies within this work and how it may contribute to the improvement of society overall, there are more generalizable lessons to be gained as well. This dissertation advanced the study of political ideology and partisanship in several other key ways. First, it used a diverse sample rather than the standard college-aged, white student sample of political science experiments. Experimental studies in political science frequently utilize samples of convenience, without substantial discussions of the limitations of this approach. The American public is diverse in race, ethnicity, and age, among other characteristics. A sample of students from a college classroom or adults from Amazon's Mechanical Turk are unlikely to be representative of true differences between ideologues or partisans nation-wide. This sample was mostly black (~60%), split equally between genders, and had a median age in the upper 20's, with a 3rd quartile of 38.5 years old. Regardless of the experimental approach, all studies should strive to use representative samples of citizens in order to make inferences about the country as a whole.

Secondly, this study improved upon extant literature by examining differences in ideology and party separately. In many experimental paradigms within political science, and in biopolitics specifically, the two concepts are treated interchangeably. To illustrate, Schreiber et al. (2013) cite Kanai's structural work examining ideological political divisions in their study of partisan political divisions. This is commonplace in the literature, and there is often no serious discussion of the potential differences between political attachments to ideology versus partisanship. While neuroimaging results were not hypothesized to differ between the groupings in these studies, evidence suggests they may. Significant structural results were found for ideological attachments, but not partisan ones. Meanwhile, significant functional results were found for partisan attachments, but not ideological ones. Whether this is an artifact of the sample distribution itself is unknown, yet these results do emphasize the importance of considering which political concept is being studied, and how it may differ across groups.

Lastly, a novel paradigm was utilized in the functional neuroimaging portion of this dissertation. Though functional imaging itself has been used in the political context, no studies to date have employed designs aimed at examining emotional processing or emotion regulation explicitly. This paradigm, and others like it, are beneficial to understanding the well-established psychological differences between liberals/conservatives or Democrats/Republicans. It is critical to apply functional designs used previously in healthy populations as a baseline to analyzing political attachments. Knowing how the average brain functions during these paradigms helps to select the right tests and form strong hypotheses.

Recommendations for Future Research

This author strongly supports the use of neurobiological approaches to the study of political attitudes and behavior in the future. The results herein, and others that came before them, provide a robust foundation for the continued study of biopolitics. In particular, more studies should evaluate the biological correlates of strength of political ideology and partisanship, in addition to the direction of political ideology and partisanship. Though limited, the findings here indicate that there is the potential to unlock a novel understanding of the neurobiological mechanisms associated with political attachments, and that this knowledge could be applied to improve societal interactions, political and non.

Another, perhaps grander, recommendation may be inspired by this work: the file drawer problem, or publication bias, must be corrected. The tendency for only statistically significant results to be published and shared across academic communities substantially hampers progress across fields, and especially in areas like neuroimaging. It is just as important to know if results from a political neuroimaging study were replicated, as it is to know if they were not. A lack of reproducibility has plagued many fields, and it would serve political science well to share all experimental results, significant or not. If a majority of studies cannot replicate structural or functional findings in other samples, we cannot draw the conclusion that these differences exist. Similarly, there is no way to know how much duplicative work has been undertaken across biopolitics, since null results garner no attention.

Finally, given the limitations of this study, and many like it, I would recommend the creation of a biopolitics databank. Currently, open sourced and free databanks do exist for housing publicly available neurological data including MRI (https://openneuro.org/). Missing from repositories such as these, of course, are measures of interest to political scientists. In fact, a search of political terms in the database offers zero results. If researchers from across institutions could share imaging data and work collaboratively to analyze larger, more diverse samples of subjects, our ability to make robust inferences would greatly increase. Much could be learned regarding the true nature of pollical ideology, partisanship, and attachment, with a biopolitics consortium and shared imaging databank.

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