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The Neuroscience of Terrorism: A Neuroscientific Approach to Understanding Cognitive-Behavioral Traits of Violent Extremists

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The neuroscience of terrorism is a newly emerging interdisciplinary topic with potential implications for national security, forensic psychology, neuroimaging, and foreign policy. The exploratory case study and literature review presented highlight some of the most important findings in neuroscience in the previous decade. This paper attempts to apply current theories of brain-behavior relationships to understanding terrorism and violent extremism. Violent extremism is essential to terrorism and terrorist organizations. We found that a neuroscientific approach can identify and formulate research questions poised to investigate terrorism and violent extremism. Ultimately, we believe that neuroscience can be used in unison with traditional counterterrorism methods to better understand the terrorist mindset.

Keywords: Neuroscience, terrorism, violence, aggression, extremism, neuroimaging

Little research has examined the role that neuroscience can play in understanding terrorism. Such a question has an interdisciplinary function because it looks at terrorism, a political science issue, in the context of brain-behavior relationships, a neuroscience issue. There are numerous core concepts to define before we begin our discussion, including terrorism, violence, and violent extremism. Terrorism is a violent act orchestrated by non-state actors against the civilian population to create fear and intimidation in the general public, with the long-term goal of achieving a political, religious, ethnic, or nationalist objective. Violence can be defined as "any behavior intended to cause extreme physical harm to another person who does not want to be harmed, such as injury or death" (Bushman, 2018, p. v). Violence can be further categorized into two subtypes: impulsive violence and instrumental violence (Bogerts, Schöne, & Breitschuh, 2018). Impulsive violence is emotionally driven and spontaneous, whereas instrumental violence is methodical and premeditated. Instrumental violence, which is premeditated and goal-oriented, would be more closely associated with terrorism, which is often meticulously calculated and organized (Bogerts et al., 2018). Violent extremism is the ideological blueprint of terrorism; it is a form of extremism where violence is often used to promote an ideology.

Violent extremism presents a challenge to public health (Rosell & Siever, 2015) and national security (Lebovic, 2007). Approximately 10,900 terrorist attacks worldwide occurred in 2017 alone, with 97 attacks occurring in North America (National Consortium for the Study of Terrorism and Responses to Terrorism, 2018). Applying certain theories of brain-behavior relationships can help researchers to understand how and why violent extremism occurs.

The Present Study

In the present study, we explored terrorism from a neuroscience perspective in the context of mental well-being, society and culture, the neural correlates of violence and aggression, neurodevelopment, and social cognition. We utilized an ex-

ploratory case study as a first-step research design in order to explore a relatively new field of scientific inquiry (Streb, 2010).

Terrorism has been studied from multiple perspectives, including international law (Travalio, 2000), developmental psychology (Locicero & Sinclair, 2008), political science (Abrahms, 2012), psychoanalysis (Jones, 2006), sociology (Turk, 2004), and more recently, neuroscience (Decety, Pape, & Workman, 2017). Terrorism researchers should continue to take on these multidisciplinary approaches. The present study contributes to a growing body of multidisciplinary terrorism research.

Method

Exploratory Case Study

The next section presents an exploratory case study featuring two of the 19 September 11 (9/11) hijackers. Our case study explored the utility of a holistic psychological approach to the study of violent extremism. This approach set the groundwork for the application of a neuroscientific spotlight on mental health and the social and developmental determinants of radicalization and violent extremism.

Literature Review

A selected literature review of recent articles in the neuroscience literature concerning the neural basis of cognitive-behavioral traits commonly associated with terrorism follows the case presentation. An initial computerized search was performed on electronic databases available in the University of Buffalo libraries. The computerized keyword search included search terms "neuroscience" or "neuroimaging," or "brain" combined with "terrorism" or "counterterrorism" or "violence" or "aggression." Additional sources were identified from bibliographies from relevant articles.

Design

Research questions were formulated from salient features of the case study and literature review. In light of limited prior investigations aimed at determining the role of neuroscience in describing terrorism, this exploratory case study and literature review provided a foundation for hypothesis generation and future research.

An Exploratory Case Study of the 9/11 Hijackers: The al-Shehri Brothers

On September 11, 2001, 19 hijackers attacked the U.S. mainland in one of the worst terrorist attacks in American history. Psychological motivations for committing terrorist acts have been heavily investigated by the mental health community for decades (Hilke & Kaiser, 1979; Srenshaw, 1988; Hudson, 1999; Weatherston & Moran, 2003; Horgan, 2005; Diamond, 2011; Lankford, 2017), with competing theories on the role of mental illness in terrorism being proposed throughout. It seems to be the consensus among scholars that mental illness is not a causal factor in terrorism, but it may be a contributing factor in some cases. As such, even in those minority of cases where mental illness does appear to be significant, it should only be viewed as part of a multivariate analysis of terrorism. Recent research has observed that mental illness was overrepresented among the 9/11 hijackers, with new evidence of mental health problems in these individuals (Lankford, 2017).

Mental Health

Among the hijackers were the al-Shehri brothers: Wail Muhammad Abdullah al-Shehri, born on July 31, 1973, aged 28, and Walid Muhammad Abdullah al-Shehri, aged 22 as of 2001. While little is known about Walid, his older brother Wail is known to have experienced depressive episodes, according to a CIA intelligence report (Lankford, 2017; CIA, 2003). According to one journalist, Abdel Rahman, one of the 11 al-Shehri brothers, reported that Wail allegedly "fell into a deep depression" in 1999, at the age of 25. Additionally, his friends described him as having a "suicidal tendency" (Sennott, 2002). This is in line with recent research on (attempted) suicide bombers, which

found that 40% of the sample appeared to have suicidal tendencies while 53% of the sample had depressive tendencies (Merari et al., 2010a).

Depression

Previous studies have found that depressed individuals were three times more likely to commit violence than non-depressed individuals from the general population (Fazel et al., 2015; Yu et al., 2017). It is plausible that untreated depression increased Wail's susceptibility toward radicalization. As previous research has shown, depression is associated with cortical and subcortical brain abnormalities, including atypical metabolic activity and reduced volume in the prefrontal, amygdala, hippocampal, and thalamic regions (Pandya, Altinay, Malone, & Anand, 2012). It was perhaps at this point, when Wail al-Shehri was most psychologically vulnerable, that he was radicalized by a militant Islamic cleric. In 2000, Wail al-Shehri took an oath to commit himself to jihad at the Seqeley mosque along with his brother and a few other hijackers. Afterward, they allegedly went to the Al Farouq training camp in Kandahar, Afghanistan (Sennott, 2002).

Boredom

In the same news report cited earlier, Rahman made a key observation about his two brothers, the al-Shehri brothers: "You have to understand my brothers were not Islamic purists. They were young, they were bored, and we have no idea what happened to them. To be very honest, neither one of them was very smart, nor very motivated to do anything." (Sennott, 2002). The fact that the al-Shehri brothers were described as "bored" is telling, given that boredom is also linked to anger and aggression (Rupp & Vodanovich, 1997). The lack of external stimulation in a region that was relatively impoverished may help explain their apparent boredom. This is important from a neuroscience perspective because boredom has implications for psychosocial development (Watt and Vodanovich, 1999). Animal studies have found that a stimulating environment is important for brain maturation (Benefiel & Greenough, 1998). Their reported lack of motivation may be an indicator of nihilism or a lack of life meaning due to underdeveloped goals. Subsequent radicalization may have catalyzed their sense of purpose and fulfilled their quest for personal significance (Kruglanski, Chen, Dechesne, Fishman, & Orehek, 2009). However, while there is always room to speculate on the terrorist personality profile, I would interpret the previous media reports with caution. Reports of Walid and Wail being "depressed" or "bored" offer only a few pieces of a more complex picture. There are certainly many other aspects of their personality which remained hidden from view, even from their friends and family. Frustration, for instance, is believed to be an important factor leading to aggression, according to classic psychiatric literature (Miller et al., 1958).

Cultural Healing Practices

Wail is known to have consulted a religious counselor or "faith healer" in Mecca. Consultations with faith healers are common practice in non-western cultures. However, this kind of practice underscores the fact that psychiatric counseling may not play as much of a significant role in treating mental health issues as religious counseling in this region due to their cultural standards (Alosaimi et al., 2014). In one report, researchers described the state of psychiatry in Saudi Arabia, stating that people from this region are primarily informed by religion, and as such, they often respond to emotional distress with religious activities, like praying, fasting, and going on a spiritual pilgrimage (Koenig et al., 2013). Psychiatry has only recently emerged as a formal discipline in the Arabian Peninsula circa 1983 (Carlisle, 2018). The interplay of cultural practices such as religion and medicine certainly influences long-term outcomes for people with depression.

While the cause of terrorist violence is certainly multifactorial, it is well known in the literature that some "religious elements" may be used

(or misused) as a part of belief systems underlying violent extremism (Rogers et al., 2007). Researchers disagree with the assertion that religion, per se, causes terrorism and that religion is more so used as a moral "excuse" for terrorist activity (Rogers et al., 2007). However, we should also consider the possibility that the faith healer Wail consulted was, in fact, a militant preacher who radicalized him at a time when he was emotionally vulnerable. Although, this is only speculative and, in all likelihood, there were numerous other bad actors who interacted with Wail during his radicalization.

Social Determinants of Radicalization

Wail and Walid al-Shehri were "muscle" hijackers on American Airlines Flight 11. The al-Shehri brothers were two of 11 children (Murphy & Ottaway, 2001). Both brothers studied at Abha Teacher Training College and attended the Seqeley mosque in Khamis Mushayt, a city inside Asir, Saudi Arabia. Wail was employed as an elementary school gym teacher, while his younger brother, Walid, was still in school studying to enter the same profession. Both brothers were single without children. Both were born in Asir. Asir is a southwestern province of Saudi Arabia described as a poor region, with weak policing and having a reputation as a "wild frontier" (National Commission on Terrorist Attacks upon the United States, 2004). This region was described by journalists as a conservative, tribal society with a high unemployment rate among young men (Lamb, 2002). In our case, however, the two brothers were educated and employed, which seems to indicate that other variables beyond socioeconomics played a more significant role in their radicalization.

Possible Sibling Effects

Given that the al-Shehri brothers were both willing to engage in violent terrorist activity, there might have been a sibling effect on such behavior. The older Wail may have influenced Walid into extremism due to the potential dominant and assertive traits often attributed to firstborn or older siblings, with later-born children often having more agreeable and submissive traits (Sulloway, 2001). In addition, a review of family studies suggested that antisocial and violent behavior is moderately heritable, indicating a possible genetic basis for violent extremism in particular (Poldrack et al., 2017; Anholt & Mackay, 2012).

Neurocognitive Development

While early life for the al-Shehri brothers was perhaps seemingly typical for young males in this region, it is important to recognize environmental factors that may have adversely impacted their brain development. These could have included limited resources for recreation, stimulation, or entertainment. Since little is known about their childhood, I can only assume a poverty of environmental stimuli as compared to my own western upbringing. People from Asir generally follow Wahhabist Islam, with the strict prohibition of cinema, theatre, dancing, drugs, and premarital relations between men and women (Lamb, 2002).

It has long been known that the environment plays a major role in neurodevelopment. Brain maturation is necessary but not sufficient for cognitive development. An enriched environment is also needed in order to afford the opportunities to practice and refine the skills associated with normal cognitive functioning (Kinsbourne & Caplan, 1979). An impoverished environment in Asir would not fully explain why the al-Shehri brothers engaged in terrorism. Yet, the brothers may have experienced a sense of relative loss. Their feelings of loss, experienced in the presence of limited opportunities for success, may have created feelings of frustration, humiliation, and victimization (Taspinar, 2009). These feelings may have later been linked to feelings of deprivation. Ultimately, radicalization may have filled their void and helped them to fulfill their desire to find meaning, but in a perverted fashion.

Radicalization

The al-Shehri brothers were reported to

have disappeared in 1999 while traveling to Medina, and upon their return home, their cousin described them as being different, having grown beards, increasingly religious, and associating with a secretive group of people. They were also described by this same cousin as being "ordinary guys" who later "changed" through some "kind of Islamic awakening." They also reportedly "heard sermons from people who came back from jihad in Afghanistan" (Lamb, 2002). These observations on personality changes and sudden intensification of ideological beliefs are indicative of radicalization. Social interactions with local community leaders, including militant preachers, likely influenced new patterns of thought and behavior in the al-Shehri brothers. Research shows "human behavior is influenced, directly and indirectly, by the presence and behavior of others. This is manifested in many phenomena studied by social psychology such as social influence, conformity, obedience, or compliance" (Decety et al., 2017, p. 6). In addition, Decety and colleagues reported that various brain regions have been implicated in social cognition, including the ventromedial prefrontal cortex (vmPFC), an area of the brain that is critically involved in social decision-making.

A closer study of how the al-Shehri brothers were radicalized may provide important insights and parallels to the Tsarnaev brothers, who were likewise radicalized and later involved in the Boston Bombings. However, important and insightful differences should emerge. The al-Shehri brothers were born and raised in a non-western environment, a relatively monocultural society, in the early stages of internet and computer technology, with lifetime exposure to conservative religion and traditional customs. In contrast, the Tsarnaev brothers lived most of their lives in a western environment, a multicultural society, in the later stages of internet and computer technology, with predominant exposure to moderate religion prior to radicalization. These are interesting differences that could help elucidate the various psychosocial trajectories into radicalization. However, such a comparison is beyond the scope of the current study.

Extant Literature: The Neuroscience of Terrorism

Mental Illness, Terrorism, and Neuroscience

One of the quintessential questions on the nature of terrorism is the potential role of mental illness. This is a contentious issue that has continued to generate discussion from opposing camps. Whenever we examine the brain basis of human behavior, especially violent extremist behaviors present in terrorism, there is often an underlying question: is the behavior being examined a result of an abnormality in the brain? While some researchers view the "terrorist mind" as essentially normal, others view it through the lens of psychopathology.

The kinds of psychological problems that may be present in terrorists fundamentally depends on whether they are a group or lone actors. For instance, recent research has raised the possibility of mental illness in some terrorist subgroups, such as lone actors (Corner, Gill, & Mason, 2016). In this study on lone-actor terrorists, researchers found a higher prevalence rate of schizophrenia, delusional disorder, and autism spectrum disorder in lone actors than the general population (Corner et al., 2016). The same authors suggested that a higher incidence of mental disorders among lone actors involved with terrorism in comparison with group actors (Corner et al., 2016).

In a short correspondence, Khoshnood (2017) concludes that the correlation between terrorism and mental illness is very weak. Based on his brief review of recent research, Khoshnood (2017) acknowledged the importance of studying radicalization's psychological factors. However, he concluded that mental illness does not play a major role in terrorism. His conclusion was based on a previous study conducted by terrorism experts (Alonso et al., 2008).

Another well-noted expert in the psychology of terrorism reported that only a minority of terrorists have a history of mental health issues (Horgan, 2005). However, Horgan's research, although

exclusive and insightful, is mostly limited to case studies. As he points out, an ongoing problem in terrorism research is the lack of access researchers have to the mental health information of terrorists. Most medical and psychiatric files on terrorists are likely to remain classified for security reasons, and mental health professionals who have access to such individuals are few. Horgan is one of the few premier researchers who has had the special privilege to interview terrorists and develop theories on the psychology of terrorism based on actual case studies.

In a theoretical article by Decety and colleagues (2017), the authors argued that radicalized individuals are mainly ordinary people, and that violent extremism does not appear to be caused by a brain disorder. The authors theorize that understanding terrorist psychology depends on a multilevel approach that integrates social, political, and economic perspectives with organizational and individual perspectives (Decety et al., 2017).

In support of the link between mental illness and terrorism, other researchers have found that terrorists are more likely to present with a history of psychosocial problems such as mental impairment, psychiatric examinations, post traumatic stress disorder, special education, violence, child abuse, criminality, anger, noncompliance with therapy, child behavioral issues, or any number of documented psychiatric illnesses such as borderline personality disorder, compulsive disorder, autism, and schizophrenia (Weenink, 2005; Merari et al., 2010a; Sahito et al., 2013; Meloy et al., 2017).

Weenink (2005) studied the police files of 140 subjects suspected of traveling or planning to travel from the Netherlands to Syria. He found that radical Islamists with a history of behavioral problems were overrepresented in these files, with 46% of the suspects exhibiting a "problem behavior." Additionally, the same study found that 6% of the sample presented with a personality disorder or mental illness. In these police files on terrorist suspects, there were indications of problem behaviors and mental illness, which included reports of mental impairment, institutionalization, child neglect, special education, persistent criminal offenses, child abuse, anger management, childhood trauma, tantrums, aggression, youth detention, and homelessness. Mental disorder diagnoses in the sample included psychosis, narcissistic personality disorder, ADHD, schizophrenia, autism spectrum disorder, and post traumatic stress disorder.

A subsequent review examined several personality disorders often suspected of terrorists, including narcissistic, paranoid, antisocial, and borderline personality disorders (Sahito et al., 2013). The study by Sahito and colleagues (2013) highlighted possible approaches to individual and group profiling of terrorists from a psychological trait perspective. These researchers proposed using psychological profiling and trait analysis as a way of guiding interrogations during counterterrorism operations.

Another study revealed that suicidal bombers were significantly more likely to present with avoidant-dependent personality disorder, depressive symptoms, and suicidal tendencies in comparison with non-suicidal terrorists and terrorist organizers (Merari et al., 2010a). Also, a forensic case study observed impulsive behavior in lone-actor terrorism (Meloy et al., 2017). Similar observations have been made of suicide bombers in comparison to non-suicide actors (Merari et al., 2010a).

Even if a purported link between mental illness and terrorism is found, there seems to be many limitations with applying psychiatric diagnoses and psychological profiling. Understanding terrorism is not just about psychopathology. Diagnosing a patient will help explain their constellation of symptoms, but it will not explain the motivation behind their behavior (Bhui et al., 2016). Understanding how individual and group processes converge offers a more comprehensive outlook on terrorist involvement. Terrorists come in a wide variety, which makes profiling impractical and even counterproductive. As one expert noted, "when we assume static qualities of the terrorist (a feature of profiles), we become blind to the quality of the dy-

namics that shape and support the development of the terrorist" (Horgan, 2008, p. 84).

We cannot fully understand terrorism in terms of any single fundamental cause or contributing factor, such as mental health. However, it is important to examine the commonality of psychological traits attributed to terrorism. They may reveal the neurological underpinnings of violent extremism. Ultimately, no definitive conclusion can be made on the role of mental illness in terrorism without evidence based on psychiatric interviews, neuropsychological testing, and neuroimaging reports. However, some useful interpretations of the available evidence can still be made. The current debate on the role of mental illness in terrorism will undoubtedly continue.

Violence, Aggression, and the Brain

The neural correlates of violence reside among various structures of the brain (Bogerts et al., 2018). Bogerts et al.'s (2018) review is truly the first of its kind and one of the only known articles to exclusively look at terrorist violence from a neuroscience perspective. One of the most intriguing observations regarding functional anatomy is that some of the same regions involved with violence and aggression are also involved with empathy (Bogerts et al., 2018), indicating that abnormal changes in these brain areas may have a dual impact on aggression and empathy alike. Empathy, or the ability to understand or share the feelings of others, is an essential trait of modern humans. Neuroscience literature has previously examined the relationship between impaired empathy and violence (Chialant, Edersheim, & Price, 2016). This study suggested that the prefrontal cortex and limbic system, under pathological conditions, are associated with violent behavior. In contrast, these same areas, under normal conditions, are associated with empathy.

Bogerts et al. (2018) reviewed various structural and functional imaging studies that found several cortical and subcortical limbic regions linked to aggression and violence. For example, violence and aggression may result from abnormalities in the cortical region, including lesions caused by trauma or tumors, decreased cortical volumes due to developmental problems, and reduced processing efficiency (Siever, 2008). Violence and aggression may also result from abnormalities in the limbic regions, including hyperactivity of the amygdala and related structures, reduced subcortical volumes, and emotional hypersensitivity (Siever, 2008).

Functional Neuroanatomy of Prefrontal Regions

The following sections will focus on prefrontal regions of the brain, as these areas are commonly associated with violence and aggression (Bogerts et al., 2018). The prefrontal cortex (PFC) constitutes one-third of the neocortex and is divided into the lateral (including ventrolateral and dorsolateral), medial, and orbitofrontal cortices (Fuster, 2001; Siddiqui, Chatterjee, Kumar, Siddiqui, & Goyal, 2008). The same authors provide the following information on regional prefrontal function. First, the lateral region is associated with language, attention, memory, response conflict, positive/negative attitude mediation, spatial reasoning, planning, novelty processing, creativity, and new learning. Second, the medial region is associated with bimanual coordination, attention to complex cognitive tasks, modulating arousal states, spatial memory, self-initiated movement, conflict resolution, decision making, long-term memory retrieval, and metacognition. Third, and finally, the orbitofrontal region is associated with reward expectations, emotional processing, delayed response, and behavioral self-regulation. In summary, PFC function is strongly associated with executive function, memory, intelligence, language, visual search, and gaze (Siddiqui et al., 2008). Notably, the orbitofrontal cortex is strongly linked to the amygdala, a limbic structure, forming an important circuit involved in violence and aggression.

Unique and common clinical symptoms characterize damage to each of the PFC subregions

(lateral, medial, and orbitofrontal cortices). Fuster (2001) describes them as follows: lesions in the lateral PFC are associated with the inability to organize and execute behaviors, speech, reasoning, and attentional control. Second, lesions in the medial PFC are associated with the loss of initiation of movement and speech, akinetic mutism, apathy, and impaired concentration. Third, lesions in the orbital PFC are associated with personality changes, impulsivity, irritability, disinhibition, amorality, and attentional deficits.

While regional specificity of functional anatomy is important, understanding the neural function of the PFC cannot be understood in isolation, but in the context of neural circuitry or the connections that the PFC has with other areas of the brain, including the brainstem, thalamus, and limbic system (Fuster, 2001). In other words, brain functioning is not exclusively localized to discrete areas but subserved by a complex network (Fuster, 2001). The PFC has reciprocal connections with all of the aforementioned regions except the limbic system's basal ganglia (Siddiqui et al., 2008). The PFC also has interconnections between its lateral, medial, and orbitofrontal subregions.

The following sections consider the segmental PFC areas that have been implicated in violence and aggression. A recent neuroimaging study found that violent offenders presented with reduced gray matter volume in the PFC and increased gray matter volume in the cerebellum and basal ganglia in comparison with non-violent controls (Leutgeb et al., 2015). Reduced gray matter volume in the PFC was also associated with psychopathy in the same subjects. Another study found reduced gray matter volume in the PFC in violent offenders and reduced functional connectivity of prefrontal areas with limbic areas (Contreras-Rodriguez et al., 2015).

Orbitofrontal Cortex (OFC). One review found that lesions in the orbitofrontal cortex were associated with increased aggression and impulsivity (Bogerts et al., 2018). In addition, reduced volume of the OFC was also observed in males with violent inclinations. This same review found that past studies have observed patterns of reduced gray matter volumes in the OFC, cingulate cortex, hippocampus, and insula in forensic and psychiatric populations. In particular, these structural abnormalities have been observed in criminals with psychopathy, in some psychiatric patients with schizophrenia or antisocial personality disorder, and in male prisoners with a history of violent offenses, including, but not limited to, homicide (Bogerts et al., 2018). Individuals with orbitofrontal lesions are more likely to have neuropsychiatric disorders, impaired social judgment, reduced empathy, and reflexive aggression (Brower & Price, 2001). An earlier review also found that both human and animal studies have implicated the PFC in aggression in cases where ablative brain surgery was performed on animals, in cases where humans underwent surgical or accidental lesions, in psychiatric patients, or in human subjects in experimental settings (Giancola, 1995). This review also found that the orbital region was more likely to be associated with disinhibited but non-aggressive behavior. In contrast, it was the dorsolateral region that was more likely to be associated with physical aggression. While some studies have been inconsistent in terms of orbital contributions to aggression, many studies point to this region as being a neural correlate of impulsivity (Winstanley et al., 2004).

Lateral Prefrontal Cortex (LPFC). The lateral PFC (LPFC) can be divided into dorsolateral and ventrolateral cortices. One review found that lesions in the dorsolateral cortex were associated with increased aggressive behavior (Brower & Price, 2001). The ventrolateral PFC is heavily involved in the cognitive control of memory, including semantic retrieval, episodic retrieval, post-retrieval selection, and task switching (Badre & Wagner, 2007). However, there seem to be limited studies on how the ventrolateral PFC contributes to violence and aggression.

In one meta-analysis by Yang and colleagues (2009), researchers analyzed 43 functional and structural neuroimaging studies on clinical

subjects characterized as antisocial. These individuals presented with any one of various disorders, including antisocial personality disorder, antisocial behavior, conduct disorder, oppositional defiant disorder, psychopathy, and individual histories of criminal behavior, violence, or aggression (Yang & Raine, 2009). This study found that individuals with antisocial personality disorder showed reduced prefrontal volume and reduced prefrontal activity. Specifically, these researchers found these reductions in various regions, including the left dorsolateral PFC, right orbitofrontal cortex, and right anterior cingulate cortex in brain scans of clinical subjects as compared to controls.

Medial Prefrontal Cortex (MPFC). In a recent review, one researcher found that dysfunctions in both the ventromedial prefrontal cortex and amygdala are associated with psychopathy, as well as impairments in reversal learning and increased reactive aggression (Blair, 2010). Experimental research has shown that ventral and dorsal aspects of the mPFC are implicated in social reactive aggression in healthy male subjects (Lotze et al., 2007). This study found increased activity in the mPFC in these subjects during an interactive fMRI task. Subjects exhibited increased dorsal mPFC activity while administering a retaliatory stimulus to their opponent during an fMRI task but exhibited increased ventral PFC activity while observing their opponent suffering. The medial PFC (mPFC) is primarily involved in memory and decision-making (Euston et al., 2012).

Functional Neuroanatomy of the Limbic System

The limbic system includes the olfactory bulb, hippocampus, amygdala, hypothalamus, basal ganglia, and cingulate gyrus. Of primary importance to the study of violence and aggression in terrorism are the amygdala, hypothalamus, and cingulate gyrus. The amygdala is nuclei located in the medial temporal lobe; the hypothalamus is in the frontal lobe, directly below the thalamus; and the cingulate gyrus is in the medial cerebral cortex, immediately above the corpus callosum. The amygdala is divided into central, basolateral, and superficial complexes (Rosell & Siever, 2015). It receives multisensory input and delivers motor signals to various other brain regions (Sah, Faber, Lopez de Armentia, & Power, 2003). The central complex generally projects efferent (motor) nerve fibers to subcortical regions and the brainstem. The basolateral complex generally receives afferent (sensory) nerve fibers from various cortical regions and the thalamus. Less is known about the superficial complex, however. Functionally, the amygdala is associated with emotional processing (including fear conditioning, aggression, and recognizing facial expressions), the hypothalamus with homeostatic function, and the cingulate gyrus with regulation of autonomic functions (Siddiqui et al., 2008).

However, brain functioning is not best understood in terms of discrete parts but by their interconnections. This is a maxim of neurology that is crucial for understanding neuropathology in violent extremism. For instance, a systems approach to understanding prefrontal-amygdala circuitry reveals that aggression can be understood in the context of top-down and bottom-up processes, with the orbitofrontal cortex and cingulate gyrus regulating aggression (through a top-down process analogous to a braking system), and the amygdala and insular triggering aggression (through a bottom-up process analogous to an accelerating system; Siever, 2008). The nature of violence from a neurological perspective should reveal a loss of balance between these two systems, with a hypoactive top-down process and a hyperactive bottom-up process.

Amygdala. A functional imaging study by da Cunha-Bang and colleagues (2017) found reduced amygdala-prefrontal connectivity and reduced striatal-prefrontal connectivity in violent offenders. These same authors found increased amygdala reactivity in this group (da Cunha-Bang et al., 2017). These findings indicate increased neural sensitivity in response to provocative stimuli, a characteristic that is often associated with aggres-

sion.

A review article by Davidson and colleagues (2000) argued that emotional dysregulation is a prelude to violence and aggression. The authors reported that the orbital frontal cortex, amygdala, anterior cingulate, and other associated regions are involved in emotional regulation. The PFC, in particular, received projections from neurons secreting serotonin, a neurotransmitter associated with regulating mood, social behavior, appetite, digestion, sleep, memory, and sexual function. A dysfunctional circuity involving the aforementioned regions may explain why individuals are more prone to impulsive aggression and violence due to emotional regulation problems. A recent review also found that bilateral volume reductions of the amygdala were associated with childhood aggression, reduced volume of the left central amygdala was associated with a lifetime history of aggression, and reduced bilateral volume of the amygdala was associated with adult men who were classified as aggressive (Pardini et al., 2014). Amygdala volumes were inconsistent in clinical samples of patients with psychopathy, however.

Development, Terrorism, and Neuroscience

The brain undergoes extraordinary structural and functional changes over time. Some areas generally develop earlier than others, and it is not uncommon to observe a healthy range of variability between individuals. Age and development have direct implications for human cognition and behavior, including rational decision-making. An examination of criminals or terrorists might reveal subjects with brains that are unlikely to have reached full maturation. Indeed, a review of terrorism research has indicated that terrorists typically join terrorist groups between 17-26 years of age (Loza, 2007). The inclination for adolescent and young adult recruitment and radicalization may be understood in terms of neurodevelopment, including developmental trajectories of cortical and subcortical regions. For instance, there appears to be a differential pattern of brain maturation where subcortical regions develop earlier and cortical regions develop later. Subcortical regions are generally associated with impulsive behaviors and primitive functions, whereas cortical regions are associated with rationalization and higher-order functions. Generally, the earlier the stage in brain development, the more time and potential the brain may have to adapt in response to stress, although resilience to stress decreases with aging. Such resiliency is present in the prefrontal cortex (McEwen & Morrison, 2013). While some lesions leave a permanent mark on cognitive or behavioral function, other injuries may be compensated for with cerebral reorganization, depending on the site and extent of the injury and chronological age. However, it is the connection between cortico-subcortical regions that may allow for regulatory functions to emerge. As such, neurodevelopment should be examined in terms of regional growth and system growth. According to research, understanding brain development is not only a matter of observing developmental changes in individual brain regions, but also the connections between regions, which are largely bidirectional and possess a hierarchical organization (Logothetis, 2008).

Neurodevelopment is tied to functional development, and as a consequence of late PFC development, higher-order functions such as logical reasoning develop later in life (Fuster, 2001). The PFC, in comparison with other cortical regions, is one of the last areas of the brain to undergo myelination and synaptogenesis, which are long-term maturational processes that often do not culminate until adolescence (Siddiqui et al., 2008). Recent neuroimaging research suggests that the prefrontal cortex does not fully develop until the third decade of the human life cycle (Fuster, 2015). These patterns of late-PFC maturation may be important in explaining violent extremism in terrorism from a neurodevelopmental perspective. It is plausible that individuals are more likely to become radicalized in these periods of adolescence and young adulthood when regulatory mechanisms are underdeveloped. However, this is speculative. Empirical

research is necessary to prove this claim.

In contrast, the amygdala develops early in life, with high rates of development occurring within two weeks of the postnatal period (see Tottenham, 2013, for review). There appears to be a sensitive time period in brain development where different regions are more susceptible to environmental influence. This kind of susceptibility is greatest during "peak periods" of neurodevelopment where specific brain regions are rapidly developing (Tottenham, 2013; Lupin et al., 2009). One researcher notes, "for some regions, like the prefrontal cortex, this period will be quite late and extended; for the amygdala, it will be early and rapid" (Tottenham, 2013, p. 4). Tottenham notes that the amygdala is particularly sensitive to environmental changes during early life.

Neurodevelopmental changes are non-linear (Gogtay & Thompson, 2010). In terms of brain volume, there is a pre-puberty increase in gray matter volume followed by a post-puberty decrease, which is explained by neurological processes of maturation, such as synaptic pruning and cortical myelination. In contrast, white matter volumes increase throughout the lifespan for several decades (Gogtay & Thompson, 2010). These changes in volumes are heterogeneous across lobes. Development is often prolonged, especially in the prefrontal region. The previously described changes in gray and white matter volume are best explained as a mechanism of improved efficiency of neural function during growth. Adult cognitive function is not so much dependent upon the number of brain cells in a given region as it is by the fine-tuned connections between cells and regions overall. Development of the PFC from 7 years to early adulthood is correlated with improvements in cognitive function, specifically with regard to processing speech, strategic thinking, working memory, and inhibition. These four abilities are linked to the dorsolateral prefrontal cortex in particular (Diamond, 2002).

There are unique behaviors associated with individuals in the adolescent-young adult age range, including increases in novelty-seeking and risk-taking (Spear, 2000). Young adults are considered to be between the ages of 20-35. The average age of the 9/11 hijackers was 24 (Central Intelligence Agency, 2008). Some suspected terrorists from other organizations also appear to fit within the young adult age range (Loza, 2007). For instance, according to a report by journalists from The Washington Post, a total of 125 individuals in the U.S. were charged by Federal prosecutors for activities in connection with the Islamic State, a jihadist militant group. This information was based on files from the U.S. Department of Justice. The average age of these individuals was 27 at the time that they were charged (Goldman et al., 2015). The age range for these individuals was 17-52.

Loza (2007) argued that some of the older terrorist leaders tend to promote martyrdom in recruits while being less likely to follow that pathway themselves. Similarly, another study conducted on the personality characteristics of suicidal terrorists, non-suicidal terrorists, or violent offenders and terrorist organizers found that both suicidal and non-suicidal terrorists had an average age of 19. In contrast, terrorist organizers had an average age of 27 (Merari et al., 2010b). This data is not surprising given the longstanding research on the age-crime curve, which shows that criminal behavior, including aggression, is correlated with males from adolescent or young adult age groups. Maturation of the brain occurs in adolescence and early adulthood, and this period is associated with a decrease in risk-taking behaviors, including criminal behavior, as the central nervous system fully develops (Blonigen, 2010).

Social Cognition, Terrorism, and Neuroscience

Social cognition encompasses several related constructs, including empathy, prosocial behavior, morality, and the regulation of violence and aggression (Decety et al., 2010). The aforementioned constructs are very important in mediating our social interaction with others. Dysfunctional social cognitive processes are often manifested as

problematic social behaviors, including violence and aggression, and may, perhaps, contribute to radicalization and associated terrorist activity. Investigating the neural mechanisms of social cognition is essential to understanding how terrorists become radicalized. Decety and colleagues (2010) argue that we can understand the neural correlates of radicalization by studying the psychological and demographic characteristics associated with extremism and analyzing patterns of brain activity in individuals with such characteristics in experiments designed to probe moral decision-making.

With the support of a social psychological model, Smith et al. (2020) proposed that radicalization is basically a group socialization process that unfolds during "situated social interactions" that optimize the influence of shared understanding and experiences. They claim, "people's radicalization to violence is inseparable from the social context in which their social interactions take place" (Smith et al., 2020, p. 327). In other words, terrorism is an evolving psychosocial process that develops within a group context and does not simply manifest itself from individual tendencies but from the influence of outside forces.

Results: Research Questions

Multiple perspectives are needed in terrorism studies given the complex interplay of genetic predispositions, individual psychopathology, socio-cultural determinants, and environmental conditions in shaping human behavior. Taken together, our exploratory case study and literature review generated research questions to be addressed through a hypothetical neuroscientific lens. Suggested research questions include:

- **Genetics**: Can our study of genes and neurodevelopment help us to predict violence and aggression in later adulthood?
- **Psychopathology**: Can neuroscientific research methods elucidate a causal or explanatory role for mental illness in the study of terrorism?
- **Psychopathology**: Is the potential for radicalization based on individual differences, i.e., age, socialization, personality, neurocognitive development, identified by neuroscientific measures?
- **Social-cultural**: Is empathy a mediator of aggression?
- **Social-cultural**: Can shared perspective-taking in groups and between siblings be explained by neuroimaging?
- **Social-cultural**: What are the neural correlates of religious fundamentalism?
- **Environmental**: Do environmental conditions impact neurodevelopment in such a way as to increase the probability of violent extremism?

Discussion: A Neuroscientific Conversation

Some researchers in terrorism studies often use inductive reasoning to infer potential brain abnormalities in terrorists based on clinical and forensic studies (Bogerts et al., 2018). That is, general principles regarding the neural correlates of violence in forensic and clinical populations are used to make probable but uncertain conclusions about terrorist suspects. Stronger evidence on the neuroscience of terrorism would certainly emerge if neuroimaging studies were to be conducted on these persons of interest. As researchers, we should readily acknowledge that there are problems with the external validity of whatever assumptions we make about the terrorist mindset, given the utter lack of informative case studies. However, we are responsible for attempting to fill the gaps in our information, although our degree of confidence will again, depend on the level of evidence on which we base our conclusions. In our case, using information from psychiatric and forensic research to apply toward terrorism research is, indeed, speculative, although it raises important questions for future research, such as the potential neural basis of violence, which appears to manifest itself in many different contexts. Neuroscience information on the terrorist population is limited because the number of available human subjects is limited, as terrorism is a rare phenomenon, and secondly because infor-

mation on these subjects is often classified due to national security reasons - and rightfully so.

I acknowledge the practical limitations that neuroscience would have within counterterrorism. Neuroimaging could only be used as a supportive analytical tool. In addition, while new evidence on the brain-behavior relationship is constantly emerging, there are still many unknowns in neuroscience.

Conclusion: The Role of Neuroscience in Understanding Terrorism

Some of the available sources that may shed light on the inner workings of the terrorist mind may include information obtained from psychiatric interviews, family narratives, military intelligence, legal proceedings, news reports, official media from terrorist organizations, and autobiographies by members or ex-members of terrorist groups. However, whatever inferences one makes should always be interpreted with caution. One should always remember the heterogeneous nature of the terrorist profile (Horgan, 2005). Generalizations should not be made as to the "neurological" characteristics of terrorists with a history of violent extremism, although some speculation is important for advancing our discussion of possible neural correlates of cognitive-behavioral traits commonly associated with this population. The role of neuroscience in understanding extremist violence may also contribute to policymaking in the legal system.

From a counterterrorism perspective, neuroscience is not a preventative tool but a supportive, analytical tool. The current psychiatric and forensic literature can help inform contemporary terrorism researchers in understanding brain-behavior relationships within the context of violent extremism. Future research should continue to investigate the functional anatomy of cognitive-behavioral traits associated with violent extremists, including violence and aggression, age-related patterns of radicalization, social cognitive processes such as empathy, and religious fundamentalism. In addition, researchers should reexamine potential links between terrorism and mental illness.

I strongly recommend that law enforcement and the intelligence community collaborate with professional neuroscientists within a legal framework in order to further investigate the neural correlates of violent extremism in terrorism. One cannot have a "multidisciplinary dialogue" about counterterrorism without neuroscience being part of the conversation.

References

Abrahms, M. (2012). The political effectiveness of terrorism revisited. *Comparative Political Studies, 45*(3), 366-393. doi:10.1177/0010414011433104

Alonso, R., Bjorgo, T., Della Porta, D., Coolsaet, R., Khosrokhavar, F., Lohker, R., ... & Taarnby, M. (2008). Radicalisation processes leading to acts of terrorism. *A concise report prepared by the European Commission's Expert Group on Violent Radicalisation.*

Alosaimi, F. D., Alshehri, Y., Alfraih, I., Alghamdi, A., Aldahash, S., Alkhuzayem, H., & Albeeeshi, H. (2014). *The prevalence of psychiatric disorders among visitors to faith healers in Saudi Arabia. Pakistan Journal of Medical Sciences, 30*(5), 1077–1082. https://doi.org/10.12669/pjms.305.5434

Anholt, R.H.H., Mackay, T.F.C. (2012). Genetics of aggression. *Annual Review of Genetics, 46*, 145-164. https://doi.org/10.1146/annurev-genet-110711-155514

Asp, E., Ramchandran, K., & Tranel, D. (2012). Authoritarianism, religious fundamentalism, and the human prefrontal cortex. *Neuropsychology, 26*(4), 414. doi:10.1037/a0028526

Badre, D., & Wagner, A. D. (2007). Left ventrolateral prefrontal cortex and the cognitive control of memory. *Neuropsychologia, 45*(13), 2883-2901. doi:10.1016/j.neuropsychologia.2007.06.015

Benefiel, A. C., & Greenough, W. T. (1998). Effects of experience and environment on the

developing and mature brain: Implications for laboratory animal housing. *ILAR Journal, 39*(1), 5-11. doi:10.1093/ilar.39.1.5

Bhui, K., James, A., & Wessely, S. (2016). Mental illness and terrorism. *BMJ, 354*, I486. doi:10.1136/bmj.i4869

Blair, R. J. R. (2007). The amygdala and ventromedial prefrontal cortex in morality and psychopathy. *Trends in Cognitive Sciences, 11*(9), 387-392. doi:10.1016/j.tics.2007.07.003

Blair, R. J. R. (2010). Psychopathy, frustration, and reactive aggression: the role of ventromedial prefrontal cortex. *British Journal of Psychology, 101*(3), 383-399. doi:10.1348/000712609X418480

Blonigen, D. M. (2010). Explaining the relationship between age and crime: Contributions from the developmental literature on personality. *Clinical Psychology Review, 30*(1), 89-100. doi:10.1016/j.cpr.2009.10.001

Bogerts, B., Schöne, M., & Breitschuh, S. (2018). Brain alterations potentially associated with aggression and terrorism. *CNS Spectrums, 23*(2), 129-140. doi:10.1017/S1092852917000463

Brandt, M. J., & Van Tongeren, D. R. (2017). People both high and low on religious fundamentalism are prejudiced toward dissimilar groups. *Journal of Personality and Social Psychology, 112*(1), 76. doi:10.1037/pspp0000076

Brower, M. C., & Price, B. H. (2001). Neuropsychiatry of frontal lobe dysfunction in violent and criminal behaviour: A critical review. *Journal of Neurology, Neurosurgery & Psychiatry, 71*(6), 720-726. doi:10.1136/jnnp.71.6.720

Burstein, A. (2018). Armies of God, armies of men: A global comparison of Secular and religious terror organizations. *Terrorism and Political Violence, 30*(1), 1-21. doi:10.1080/09546553.2015.1135424

Bushman, B. J. (2017). Editorial overview: Aggression and violence. *Current Opinion in Psychology, 19*, iv-vi. doi:0.1016/j.copsyc.2017.12.001

Carlisle J. (2018). Mental health law in Saudi Arabia. *BJPsych International, 15*(1), 17–19. https://doi.org/10.1192/bji.2017.10

Central Intelligence Agency. (2008, June 20). DCI testimony before the joint inquiry into terrorist attacks against the United States. https://www.cia.gov/news-information/speeches-testimony/2002/DCI_18_June_testimony_new.pdf.

Central Intelligence Agency. (2003, June 1). 11 September: The plot and the plotters. https://www.documentcloud.org/documents/368989-2003-06-01-11-september-the-plot-and-the.html

Chialant, D., Edersheim, J., & Price, B. H. (2016). The dialectic between empathy and violence: An opportunity for intervention? *The Journal of Neuropsychiatry and Clinical Neurosciences, 28*(4), 273-285. https://doi.org/10.1093/scan/nsv069

Contreras-Rodríguez, O., Pujol, J., Batalla, I., Harrison, B. J., Soriano-Mas, C., Deus, J., ... & Pifarré, J. (2015). Functional connectivity bias in the prefrontal cortex of psychopaths. *Biological Psychiatry, 78*(9), 647-655. https://doi.org/10.1016/j.biopsych.2014.03.007

Corner, E., Gill, P., & Mason, O. (2016). Mental health disorders and the terrorist: A research note probing selection effects and disorder prevalence. *Studies in Conflict & Terrorism, 39*(6), 560-568. https://doi.org/10.1080/1057610X.2015.1120099

Da Cunha-Bang, S., Fisher, P. M., Hjordt, L. V., Perfalk, E., Persson Skibsted, A., Bock, C., ... & Knudsen, G. M. (2017). Violent offenders respond to provocations with high amygdala and striatal reactivity. *Social Cognitive and Affective Neuroscience, 12*(5), 802-810. https://doi.org/10.1093/scan/nsx006

Davidson, R. J., Putnam, K. M., & Larson, C. L. (2000). Dysfunction in the neural circuitry of emotion regulation--a possible prelude to violence. *Science, 289*(5479), 591-594.

Decety, J. (2010). The neurodevelopment of empathy in humans. *Developmental Neuroscience, 32*(4), 257-267. https://doi.org/10.1159/000317771

Decety, J., Pape, R., & Workman, C. I. (2017). A multilevel social neuroscience perspective on radicalization and terrorism. *Social Neuroscience, 13*(5), 511-529.https://doi.org/10.1080/17470919.2017.1400462

Deckard, N.D., & Jacobson, D. (2015). The prosperous hardliner: Affluence, fundamentalism, and radicalization in Western European Muslim communities. *Social Compass, 62*(3), 412-433. https://doi.org/10.1177/0037768615587827

Diamond, S.A. (2011, May 2). On the violent life and death of Osama bin Laden: A psychological post-mortem. *Psychology Today*. https://www.psychologytoday.com/us/blog/evil-deeds/201105/the-violent-life-and-death-osama-bin-laden-psychological-post-mortem

Diamond, A. (2002). Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry. *Principles of Frontal Lobe Function,* 466-503. https://doi.org/10.1093/acprof:oso/9780195134971.003.0029

Euston, D. R., Gruber, A. J., & McNaughton, B. L. (2012). The role of medial prefrontal cortex in memory and decision making. *Neuron, 76*(6), 1057-1070. https://doi.org/10.1016/j.neuron.2012.12.002

Fazel, S., Wolf, A., Chang, Z., Larsson, H., Goodwin, G. M., & Lichtenstein, P. (2015). Depression and violence: A Swedish population study. *The Lancet Psychiatry, 2*(3), 224-232. https://doi.org/10.1016/S2215-0366(14)00128-X

Fuster, J. M. (2001). The prefrontal cortex—an update: Time is of the essence. *Neuron, 30*(2), 319-333. https://doi.org/10.1016/S0896-6273(01)00285-9

Fuster, J. M. (2015). The Prefrontal Cortex (5th ed.). *Academic Press*.

Giancola, P. R. (1995). Evidence for dorsolateral and orbital prefrontal cortical involvement in the expression of aggressive behavior. *Aggressive Behavior, 21*(6), 431-450. https://doi.org/10.1002/1098-2337(1995)21:6<431::AID-AB2480210604>3.0. C.O.;2-Q

Gogtay, N., & Thompson, P. M. (2010). Mapping gray matter development: implications for typical development and vulnerability to psychopathology. *Brain and Cognition, 72*(1), 6-15. https://doi.org/10.1016/j.bandc.2009.08.009

Goldman, A., Yang, J. L., Sharma, S., & Tate, J. (2015, June 22). The Islamic State's suspected inroads into America. *The Washington Post.* https://www.washingtonpost.com/graphics/national/isis-suspects/?utm_term=.ecce34ef6110

Higgins, E. S. & George, M.S. (2013). The neuroscience of clinical psychiatry: *The pathophysiology of behavior and mental illness*. Lippincott Williams & Wilkins.

Hilke, R., & Kaiser, H. J. (1979). Terrorism: Can psychology offer a solution to this problem? *Psychologische Rundschau, 30*(2), 88-98.

Horgan, J. (2005). The psychology of terrorism. *Routledge*.

Horgan, J. (2008). From profiles to pathways and roots to routes: Perspectives from psychology on radicalization into terrorism. *The ANNALS of the American Academy of Political and Social Science, 618*(1), 80-94. https://doi.org/10.1177/0002716208317539

Hudson, R.A. (1999). Sociology and psychology of terrorism: Who becomes a terrorist and why? *The Lyons Press*.

Jones, J. W. (2006). Why does religion turn violent?: A psychoanalytic exploration of religious terrorism. *The Psychoanalytic Review, 93*(2), 167-190. https://doi.org/10.1521/prev.2006.93.2.167

Khoshnood, A. (2017). The correlation between mental disorders and terrorism is weak. *Psychiatric Bulletin, 41*(1), 56-56. https://doi.org/10.1192/pb.41.1.56

Kinsbourne, M. and Caplan, P.J. (1979). Children's learning and attention problems. *Little, Brown and Company*.

Koenig, H. G., Al Zaben, F., Sehlo, M. G., Khalifa, D. A., & Al Ahwal, M. S. (2013). Current state of psychiatry in Saudi Arabia. *The International Journal of Psychiatry in Medicine, 46*(3),

223-242. https://doi.org/10.2190/PM.46.3.a

Koopmans, R. (2015). Religious fundamentalism and hostility against out-groups: A comparison of Muslims and Christians in Western Europe. *Journal of Ethnic and Migration Studies, 41*(1), 33-57. https://doi.org/10.1080/1369183X.2014.935307

Kruglanski, A. W., Chen, X., Dechesne, M., Fishman, S., & Orehek, E. (2009). Fully committed: Suicide bombers' motivation and the quest for personal significance. *Political Psychology, 30*(3), 331-357. https://doi.org/10.1111/j.1467-9221.2009.00698.x

Lankford, A. (2017). A psychological re-examination of mental health problems among the 9/11 terrorists. *Studies in Conflict & Terrorism, 41*(11), 1-24. https://doi.org/10.1080/1057610X.2017.1348742

Lebovic, J.H. (2007). Deterring international terrorism and rogue states: U.S. national security policy after 9/11. Routledge.

Leutgeb, V., Leitner, M., Wabnegger, A., Klug, D., Scharmüller, W., Zussner, T., & Schienle, A. (2015). Brain abnormalities in high-risk violent offenders and their association with psychopathic traits and criminal recidivism. *Neuroscience, 308*, 194-201. https://doi.org/10.1016/j.neuroscience.2015.09.011

Locicero, A. & Sinclair, S. J. (2008). Terrorism and terrorist leaders: Insights from developmental and ecological psychology. *Studies in Conflict & Terrorism, 31*(3), 227-250. https://doi.org/10.1080/10576100701879638

Logothetis, N. K. (2008). What we can do and what we cannot do with fMRI. *Nature, 453*(7197), 869. https://doi.org/10.1038/nature06976

Lotze, M., Veit, R., Anders, S., & Birbaumer, N. (2007). Evidence for a different role of the ventral and dorsal medial prefrontal cortex for social reactive aggression: An interactive fMRI study. *Neuroimage, 34*(1), 470-478. https://doi.org/10.1016/j.neuroimage.2006.09.028

Loza, W. (2007). The psychology of extremism and terrorism: A Middle-Eastern perspective. *Aggression and Violent Behavior, 12*(2), 141-155. https://doi.org/10.1016/j.avb.2006.09.001

McEwen, B. S. & Morrison, J. H. (2013). The brain on stress: vulnerability and plasticity of the prefrontal cortex over the life course. *Neuron, 79*(1), 16-29. https://doi.org/10.1016/j.neuron.2013.06.028

Meloy, J. R., & Pollard, J. W. (2017). Lone actor terrorism and impulsivity. *Journal of Forensic Sciences, 62*(6), 1643-1646. https://doi.org/10.1111/1556-4029.13500

Merari, A., Diamant, I., Bibi, A., Broshi, Y., & Zakin, G. (2010a). Personality characteristics of "self martyrs"/"suicide bombers" and organizers of suicide attacks. *Terrorism and Political Violence, 22*(1), 87-101. https://doi.org/10.1080/09546550903409312

Merari, A., Fighel, J., Ganor, B., Lavie, E., Tzoreff, Y., & Livne, A. (2010b). Making Palestinian "martyrdom operations"/"suicide attacks": Interviews with would-be perpetrators and organizers. *Terrorism and Political Violence, 22*(1), 102-119. https://doi.org/10.1080/09546550903409403

Miller, N. E., Mowrer, O. H., Doob, L. W., Dollard, J., & Sears, R. R. (1958). Frustration-aggression hypothesis. In C. L. Stacey & M. DeMartino (Eds.), Understanding human motivation (pp. 251–255). Howard Allen Publishers.

Murphy, C. & Ottaway, D.B. (2001, September 25). Some light shed on Saudi suspects. *The Washington Post*. https://www.washingtonpost.com/archive/politics/2001/09/25/some-light-shed-on-saudi-suspects/070c8fde-a24c-4f39-b6cd-9dbaee85bf4a/?utm_term=.63534ed6e957

National Commission on Terrorist Attacks upon the United States. (2004). The 9/11 commission report. https://govinfo.library.unt.edu/911/report/911Report.pdf

National Consortium for the Study of Terrorism and Responses to Terrorism (START). (2018). Global terrorism database [Data set]. https://www.start.umd.edu/pubs/START_GTD_Over-

view2017_July2018.pdf

Pal, S., & Sinha, C. (2016). Religious fundamentalism, right wing authoritarianism and homophobia among Hindus. *Indian Journal of Health and Wellbeing, 7*(7), 717.

Pandya, M., Altinay, M., Malone, D. A., & Anand, A. (2012). Where in the brain is depression? *Current Psychiatry Reports, 14*(6), 634-642. https://doi.org/10.1007/s11920-012-0322-7

Pardini, D. A., Raine, A., Erickson, K., & Loeber, R. (2014). Lower amygdala volume in men is associated with childhood aggression, early psychopathic traits, and future violence. *Biological Psychiatry, 75*(1), 73-80.

Poldrack, R. A., Monahan, J., Imrey, P. B., Reyna, V., Raichle, M. E., Faigman, D., & Buckholtz, J. W. (2017). Predicting violent behavior: What can neuroscience add? *Trends in Cognitive Sciences, 22*(2), 111-123. https://doi.org/10.1016/j.tics.2017.11.003

Rogers, M. B., Loewenthal, K. M., Lewis, C. A., Amlôt, R., Cinnirella, M., & Ansari, H. (2007). The role of religious fundamentalism in terrorist violence: A social psychological analysis. *International Review of Psychiatry, 19*(3), 253-262. https://doi.org/10.1080/09540260701349399

Rosell, D. R. & Siever, L. J. (2015). The neurobiology of aggression and violence. *CNS Spectrums, 20*(3), 254-279. https://doi.org/10.1017/S109285291500019X

Rupp, D. E. & Vodanovich, S. J. (1997). The role of boredom proneness in self-reported anger and aggression. *Journal of Social Behavior and Personality, 12*(4), 925. http://psycnet.apa.org/record/1997-38871-006

Sah, P., Faber, E. L., Lopez de Armentia, M., & Power, J. (2003). The amygdaloid complex: Anatomy and physiology. *Physiological Reviews, 83*(3), 803-834. https://doi.org/10.1152/physrev.00002.2003

Sahito, F., Slany, W., Zaman, S., Sahito, I., & Qaiser, R. (2013). Terrorist profiling as a counter-insurgency strategy: Applying the concept to law enforcement. *International Journal of Innovation and Applied Studies, 4*(2): 274-285. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2313331

Schjoedt, U. (2009). The religious brain: A general introduction to the experimental neuroscience of religion. *Method & Theory in the Study of Religion, 21*(3), 310-339. https://doi.org/10.1163/157006809X460347

Sennott, C.M. (2002, March 3). Before oath to jihad, drifting and boredom. *The Boston Globe*. http://archive.boston.com/news/packages/underattack/news/driving_a_wedge/part1_side.shtml

Siddiqui, S. V., Chatterjee, U., Kumar, D., Siddiqui, A., & Goyal, N. (2008). Neuropsychology of prefrontal cortex. *Indian Journal of Psychiatry, 50*(3), 202. https://doi.org/10.4103/0019-5545.43634

Siever, L. J. (2008). Neurobiology of aggression and violence. *American Journal of Psychiatry, 165*(4), 429-442. https://doi.org/10.1176/appi.ajp.2008.07111774

Smith, L. G., Blackwood, L., & Thomas, E. F. (2020). The need to refocus on the group as the site of radicalization. *Perspectives on Psychological Science, 15*(2), 327-352. https://doi-org.ezproxy.cul.columbia.edu/10.1177/174569

Spear, L. P. (2000). Neurobehavioral changes in adolescence. *Current Directions in Psychological Science, 9*(4), 111-114. https://doi.org/10.1111/1467-8721.00072

Streb, C.K. (2010). Exploratory case study. In A. J. Mills, Gabrielle Durepos & Elden Wiebe (Eds.). Encyclopedia of case study research (pp. 373-374). Sage Publications. http://dx.doi.org/10.4135/9781412957397.n139

Srenshaw, M. (1988). The subjective reality of the terrorist: Ideological and psychological factors in terrorism. *In Current perspectives on international terrorism* (pp. 12-46). Palgrave Macmillan.

Taşpınar, Ö. (2009). Fighting radicalism, not "terrorism": Root causes of an international actor redefined. SAIS Review of International Affairs, 29(2), 75-86. https://www.brookings.edu/wp-

content/uploads/2016/06/summer_fall_radicalism_taspinar.pdf

Thompson, S. K. (2004). The legality of the use of psychiatric neuroimaging in intelligence interrogation. *Cornell Law Review, 90*(6), 1601-1638.

Tottenham, N. (2012). Human amygdala development in the absence of species expected caregiving. *Developmental Psychobiology, 54*(6), 598-611. https://doi.org/10.1002/dev.20531

Travalio, G. M. (2000). Terrorism, international law, and the use of military force. Wisconsin *International Law Journal, 18*(1), 145-1923.

Turk, A. T. (2004). Sociology of terrorism. *Annual Review of Sociology, 30*, 271-286. https://doi.org/10.1146/annurev.soc.30.012703.110510

Watt, J. D. & Vodanovich, S. J. (1999). Boredom proneness and psychosocial development. *The Journal of Psychology, 133*(3), 303-314. https://doi.org/10.1080/00223989909599743

Weatherston, D. & Moran, J. (2003). Terrorism and mental illness: Is there a relationship?. *International Journal of Offender Therapy and Comparative Criminology, 47*(6), 698-713. https://doi.org/10.1177/0306624X03257244

Weenink, A. W. (2015). Behavioral problems and disorders among radicals in police files. *Perspectives on Terrorism, 9*(2), 17-33. https://www.jstor.org/stable/26297357

Winstanley, C. A., Theobald, D. E., Cardinal, R. N., & Robbins, T. W. (2004). Contrasting roles of basolateral amygdala and orbitofrontal cortex in impulsive choice. *Journal of Neuroscience, 24*(20), 4718-4722. https://doi.org/10.1523/JNEUROSCI.5606-03.2004

Yang, Y. & Raine, A. (2009). Prefrontal structural and functional brain imaging findings in antisocial, violent, and psychopathic individuals: a meta-analysis. *Psychiatry Research: Neuroimaging, 174*(2), 81-88. https://doi.org/10.1016/j.pscychresns.2009.03.012

Yilmaz, M. E. (2006). Religious fundamentalism and conflict. *Journal of Human Sciences, 3*(2). https://www.researchgate.net/publication/26449972_Religious_fundamentalism_and_conflict

Yu, R., Aaltonen, M., Branje, S., Ristikari, T., Meeus, W., Salmela-Aro, K., ... & Fazel, S. (2017). Depression and violence in adolescence and young adults: Findings from three longitudinal cohorts. *Journal of the American Academy of Child & Adolescent Psychiatry, 56*(8), 652-658. https://doi.org/10.1016/j.jaac.2017.05.016

Zhong, W., Cristofori, I., Bulbulia, J., Krueger, F., & Grafman, F. (2017). Biological and cognitive underpinnings of religious fundamentalism. *Neuropsychologia, 100*, 18-25. https://doi.org/10.1016/j.neuropsychologia.2017.04.009