2016

The fragmentation of self and others: the role of the default mode network in post-traumatic stress disorder

Aldrich Chan

Pepperdine University

Graduate School of Education and Psychology

THE FRAGMENTATION OF SELF AND OTHERS:
THE ROLE OF THE DEFAULT MODE NETWORK IN
POST-TRAUMATIC STRESS DISORDER

A clinical dissertation submitted in partial satisfaction

of the requirements for the degree of

Doctor of Psychology

by

Aldrich Chan

April, 2016

Louis Cozolino, Ph.D. – Dissertation Chairperson

This clinical dissertation, written by

Aldrich Chan

under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

DOCTOR OF PSYCHOLOGY

Doctoral Committee:

Louis Cozolino, Ph.D. – Chairperson

Aaron Aviera, Ph.D.

Susan Himelstein, Ph.D.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

DEDICATION

I would like to dedicate this dissertation to all survivors of trauma.

May you kindle a light of meaning in the darkest of hours

May your fictional truths play in the spotlight of your mind

May you make peace with your demons and be cradled by your values

May you find unity and love in the process

Aldrich Chan

Los Angeles, California

March, 2016

ACKNOWLEDGMENTS

It is with tremendous gratitude that I acknowledge Dr. Louis Cozolino for his guidance in the thick brush strokes of life, neuroscience and psychology. His mentorship has challenged me to rise beyond my current skill set and adopt novel ways of thinking. With deep respect, I would also like to recognize Dr. Aaron Aviera for his superb supervision, raising my awareness of the intersubjective field and introducing me to the world of somatic experiencing. I would like to thank Dr. Susan Himelstein for fomenting my growth as a clinician and supporting me along the way.

I would like to express my appreciation to Dr. Edward Shafranske for unveiling the profound importance of subjective experience and symbolic play through his supervision. Likewise, I am very appreciative of Dr. Shelly Harrell, whose presence will always be a reminder that my work is rooted in humanity. My sincerest gratitude to Dr. Daniel Siegel, his encouragement and work has continued to inspire me to think creatively, globally, and empathically.

I am ever grateful for my mother, father and brother for being so present and supportive in all of my endeavors.

VITA

EDUCATION

Pepperdine University, Los Angeles, CA September 2012-Present
Doctor of Psychology in Clinical Psychology
Anticipated Graduation: September 2016
Dissertation Chair: Louis Cozolino, Ph.D.
Title: The Fragmentation of Self and Others: The Role of the Default Mode Network in PTSD

The Chicago School of Professional Psychology, Los Angeles, CA December 2011
Master of Arts in Clinical Psychology, Specialization in Marriage and Family Therapy

Carleton University, Ottawa, Canada September 2009
Bachelor of Arts with Honors in Psychology

LANGUAGES

Spanish: Advanced Level: Competent in Therapy and Assessment.
Cantonese: Intermediate level of speaking.

CLINICAL EXPERIENCE

University of Miami/Jackson Memorial Hospital, Miami, FL July 2015-Present
Ryder Trauma Center
Pre-Doctoral Fellow – Neuropsychology Intern
Licensed Clinical Supervisor: Susan Ireland, Ph.D., Gisela Puentes, Psy.D., Sheba Kumbhani, Ph.D., Diane Netto, Ph.D.

Cedars-Sinai Medical Center, West Hollywood, CA July 2014-June 2015
Department of Physical Medicine and Rehabilitation
Adult Neuropsychology Extern
Licensed Clinical Supervisor: Jeffrey Wertheimer, Ph.D., ABPP-CN, Miyeoung Jo Ph.D., ABPP-CN, Ludmila Zaytsev Ph.D., Dale Sherman, Ph.D, Anne Gottuso, Ph.D.

Children's Hospital Los Angeles, Los Angeles, CA October 2014-June 2015
Department of Orthopaedics and Sports Medicine
Pediatric Neuropsychology Extern
Licensed Clinical Supervisor: Anita Hamilton, Ph.D., ABPP-CN

Union Rescue Mission, Los Angeles, CA Sept. 2012-June 2015
Psychology Extern
Licensed Clinical Supervisor: Aaron Aviera, Ph.D., Edward Shafranske, Ph.D., ABPP (September 2014)

Pepperdine Community Mental Health Clinic, Los Angeles, CA June 2013-June 2015
Psychology Extern
Licensed Clinical Supervisor: Aaron Aviera, Ph.D., Edward Shafranske, Ph.D., ABPP (September 2014)

Children's Hospital Los Angeles, Los Angeles, CA July 2013-July 2014
Department of Orthopaedics and Sports Medicine
Pediatric Neuropsychology Extern
Licensed Clinical Supervisor: Anita Hamilton, Ph.D., ABPP-CN

Positive Alternatives for Youth, Panorama City, CA January 2011-December 2011
MFT Trainee
Licensed Clinical Supervisors: Vickie Parker, LMFT and Joni Edelman, LMFT

ACADEMIC HONORS/AWARDS
Conrad Hilton Foundation Fellowship Fall 2012

- Fellowship endowed for working with underserved populations

CLINICAL SUPERVISION AND TEACHING EXPERIENCE
Pepperdine University, Los Angeles, CA September 2014-July 2015
Peer Supervisor
Aaron Aviera, Ph.D.

Pepperdine University, Los Angeles, CA September 2014- December 2015
Teaching Assistant – Clinical Neuropsychology
Harold Burke, Ph.D., ABMP

Pepperdine University, Los Angeles, CA September 2013- December 2013
Faculty Assistant – Cognitive Foundations of Psychology
Louis Cozolino, Ph.D.

The Chicago School of Professional Psychology, Los Angeles, CA Sept. 2011-March 2012
Teaching Assistant – Biological Basis of Behavior
Richard Sinacola, Ph.D.

RESEARCH EXPERIENCE
Mindsight Institute, Santa Monica, CA October 2014-Present
Mindsight Intern
Daniel J. Siegel, M.D.

Carleton University, Ottawa, Canada October 2011-October 2012
Carleton Department of Neuroscience & Child Studies
Research Assistant
Amedeo D'Angiulli, Ph.D.

Carleton University, Ottawa, Canada September 2009-Nov. 2009
Carleton Department of Neuroscience & Child Studies
Research Assistant
Amedeo D'Angiulli, Ph.D.

PUBLICATIONS

Siegel, D. & **Chan, A.** (2016) Play and the Default Mode: Interpersonal Neurobiology, Self and Creativity. Manuscript in preparation.

D'Angiulli, A., Runge, M., Faulker, A., Zakizadeh, J., **Chan, A.,** & Morcos, S. (2013). Vividness of visual imagery and incidental recall of verbal cues, phenomenological availability reflects long term memory accessibility. *Frontiers in Psychology, 4*(1).

Chan, A. (2012). Review of "Imagine that*:* Studies in Imagined Interactions*." Journal of Imagination, Cognition and Personality, 32*(1), 95-100.

PRESENTATIONS

Cedars-Sinai Medical Center*,* Los Angeles, CA May 2015
Samuel Oschin Comprehensive Cancer Institute

- Presented on the relevance of Acceptance and Commitment based therapy and Mindsight for patients with cancer and faculty at Cedars-Sinai

Union Rescue Mission, Los Angeles, CA September 2013

- Presented on chronic pain to a group of homeless men residing at a shelter

Positive Alternatives for Youth, Panorama City, CA August 2011

- Presented the effects of substances on the brain to a high school

The Chicago School of Professional Psychology, Los Angeles, CA November 2011

- Guest Lectured on "The Effects of Psychotherapy on the Brain" to two Masters level classes

VOLUNTEER EXPERIENCE

Cross-Cultural Solutions, Bahia, Brazil April 2012 – May 2012
Dissertation Assistant, Los Angeles, CA October 2011-December 2011
United Planet, Cusco, Peru (120 hours) June-July 2008
Habitat for Humanity, San Jose, Costa Rica 2004-2005
ADA tutoring, San Jose, Costa Rica 2004-2005
Big Brother/Big Sister program, San Jose, Costa Rica 2003-2005

AFFILIATIONS

Member of Global Association for Interpersonal Neurobiology
Member of the International Neuropsychology Society
Division 40: Clinical Neuropsychology
Division 56: Trauma Psychology
Division 22: Rehabilitation Psychology

ABSTRACT

In Post-Traumatic Stress Disorder (PTSD), social and emotional dysfunction has been interpreted as a secondary consequence of the broad impact of amygdala and fear circuitry dysregulation. However, research in social neuroscience has uncovered a number of neural systems involved in attachment and emotional regulation that may be impacted by trauma. One example is the Default Mode Network (DMN), which is implicated in human beings' sense of self and ability to connect with others.

This qualitative study explored the impact of physical and emotional traumata on the structures and functions of the DMN. The goal was to determine if dysregulation of the DMN could account for aspects of the psychological and social dysfunction found in PTSD. This study explored the following two questions:

1. What does the research literature tell us about the role of the DMN?
2. How does trauma impact DMN functioning?

The DMN has been associated primarily with autobiographical recall, self-referential processing, social cognition, prospection, and moral sensitivity. The DMN appears to support internal reflective capacity, further maintaining and connecting self-functions and social cognition. Trauma results in internetwork rigidity, as well as overall reductions in DMN activity, volume, and connectivity. These objective changes result in a Traumatized Resting State (TRS), characterized by increased Salience Network connectivity and reductions in Central Executive functioning. Studies suggest that a TRS develops in reaction to acute trauma, even before the development of PTSD, and may continue despite the stabilization of other networks. Overall, DMN incoherence significantly disrupts core psychosocial processes.

Chapter 1: Introduction and Background

It is currently estimated that the human body is composed of 37.2 trillion cells (Bianconi et al., 2013). These cells are relationally bound, forming a web of complexity and intelligence. Over the course of human evolution, cell activity led to differentiation, resulting in the emergence of distinct anatomical functions. The brain is predicted to be composed of 86 billion neurons (Herculano-Houzel, 2009). For millions of years, human brains have evolved in adaptation to their environment. Natural selection, epigenetics, exaptation, and interacting experiences led to the development of specialized neural systems, increasing the potential for humans to survive, and even thrive, under precarious and often unpredictable conditions. As brains advanced in their development, so did they give rise to a sense of self, importantly, providing humans with the capacity to introspect, creating a window into another aspect of the natural world, that is, the world as it is reflected in the mind. From reactive organisms guided by instinctual impulses to thinking beings that harbor curiosity, interests, and abstract thought, the trajectory of evolution has certainly generated features that distinguish humans from other animals. Despite such advantages, an increase in the complexity of a system is often paralleled by an increase in possible problems, one example being high rates of mental disorders (World Health Organization, 2004).

The Default Mode Network

Human experience is significantly defined by the ability to retrieve memories, evaluate present experiences, and construct imagined scenarios. Many of the distinguishing characteristics of humans rest on their ability to view themselves as objects of their own reflection. These metacognitive capacities provide humans with a unique opportunity to further the development of a self, intentionally increase awareness, and improve relationships with others, therefore optimizing survival advantage. In fact, humans spend an estimated 46.9% of their time engaged in such introspective processes (Killingsworth & Gilbert, 2010).

Marcus Raichle's (2010) research group found only a slight decrease of the brain's intake of energy when resting (less than 5%). In addition, they established that approximately 60-80% of the brain's energy consumption is dedicated to internally directed processes, independent of external stimuli. Elevated activations found in regions of the brain during resting state reflect a *Default Mode* of brain functioning (Raichle et al., 2001), that has since been termed the Default Mode Network (DMN).

The DMN is characterized by coherent low frequency neuronal oscillations (0.1 Hz) that decrease during goal-directed activity, whilst returning to its frequency state during an engagement with introspective processes (Broyd et al., 2009). Sonuga-Barke and Castellanos (2007) postulated that this coherence is indicative of temporal synchrony between the various regions of the brain associated with the DMN. This synchrony suggests the existence of interconnected processes functioning in harmony.

The Default Mode Network: Function

Brain lesions, imaging, post-mortem studies, and research on psychological, psychiatric, and neurological conditions have all contributed to compounding evidence supporting the close relationship between neural and mental functioning (Lezak, Howieson, Bigler, & Tranel, 2012). In this vein, it is logical to think that the experience of subjectivity, and the mental capacity enabling this experience, may relate to DMN activity. In fact, the DMN has been correlated with functions such as autobiographical recall, prospection (Spreng, Mar, & Kim, 2009), self-referential processing (Lanius, Bluhm, & Frewen, 2011), social cognition (Mars et al., 2012), and moral sensitivity (Reniers et al., 2012). Understanding how these functions have been defined will provide deeper insight into how these fundamental processes fit together, facilitating the overall experience of subjectivity. Moreover, such an understanding will provide the grounds to understand how pathological processes and DMN dysfunction may lead to psychological disarray.

Autobiographical recall refers to the process of remembering the past. According to Spreng and colleagues (2009), reconstructing a scene from autobiographical memory requires the projection of oneself into past memories and the retrieval of spatial and temporal information. The ability to remember the past allows people to learn from their mistakes and the mistakes of others. Importantly, this capacity also serves as the bedrock for the development of identity and the formation of a coherent self.

Along with the ability to remember past events, the DMN has been found to be active when an individual imagines the future, an ability known as *prospection*. Mental simulation of several potential futures is adaptive, as it enables one to plan in advance in order to maximize the chances of meeting a goal (Spreng et al., 2009). This capacity builds upon autobiographical recall, utilizing one's ability to retrieve historical information to further improve one's current state. Notably, imagination can be just as maladaptive as it can be adaptive, as some simulations of the future may be negatively biased due to their contingency upon the experiences of an individual's history. A traumatic history may result in a form of cognitive rigidity that constricts the application of adaptive and functional solutions. This process further promulgates anxiety and helplessness that may have once served as a successful defense against the trauma experienced (Cozolino, 2010).

Self-referential processing is the process of developing mental representations that are particularly related to the self or with *reference* to the self (Wagner, Haxby, & Heatherton, 2012). These representations may have a positive, neutral, or negative valence. An individual's biological constitution and developmental experiences determine the degree to which self-referencing and self-reflection become positive or negative experiences. Biases in cognitive-affective SRPs will influence the organism's behavior in its environment, resulting in adaptive or maladaptive decision-making processes. Given the interdependent nature of such processes, a positive or negative perception may affect one's perception of others and ultimately one's interpersonal functioning (Frewen et al., 2011). Not surprisingly, a person's capacity to be aware of emotions is intimately connected with his/her ability to reflect on his/her own internal process (Lanius et al., 2011). Flexibility and accuracy in social cognition are thus contingent upon the quality of internal development, as well as the capacity for self-reflection.

In this context, social cognition has been associated with DMN functioning and may be defined as "the perception, interpretation and processing of all information relating to a person's environment and relationship" (Moskowitz, as cited in Nietlisbach & Maercker, 2009, p. 383). Nietlisbach and Maercker (2009) identified four social cognitive functions necessary for successful social interactions: theory of mind, empathy, emotional resonance, and experiences of perceived social exclusion. Two key elements in this construct are theory of mind and empathy. Theory of mind (ToM) is the ability to imagine the thoughts and feelings of others (Spreng & Grady, 2010). ToM is cognitive (Nietlisbach & Maercker, 2009) and necessitates an observer to be capable of recognizing that another has a mind and assume what that mental state is (Saxe, 2006). Saxe (2006) emphasized another level to consider, called *representational theory of mind*, which is how a mental state is represented in the other. Empathy is affective in nature (Nietlisbach & Maercker, 2009) and can be defined as a shared emotional state that emerges as a result of the observation of and imagination about another person's emotional state (Gallese, 2003). ToM is subsumed in empathy (Nazarov et al., 2014). Emotional resonance is a non-conscious capacity whereby an individual automatically engages in an implicit response (affective resonance) via detection of non-verbal communications and other social signals, made possible by neurobiological mechanisms and circuitry dedicated to social processing (i.e., mirror neurons, spindle cells, the DMN; Nietlisbach & Maercker, 2009). With the capacity for effective interpersonal communication, social experiences become consolidated and reflected upon without perturbation. In contrast, perceived social exclusion from a community may have meant death in humanity's evolutionary history. Thus, survival may depend on the ability to detect rejection. In fact, lacking positive relationships often leads to "loneliness, guilt, jealousy, anxiety, and depression…higher incidences of psychopathology and have reduced immune functioning" (Nietlisbach & Maercker, 2009, p. 393).

With each interconnected function building on one another, researchers have also found that moral decision-making recruits DMN activation (Reniers et al., 2012). Reniers and colleagues (2012) further characterized moral decision-making as based on the internalization of socially and societally accepted values of a particular environment, followed by the evaluation of actions based on these values. The consistent application of these moral principles in everyday decision-making is what Lind (2008) has termed *moral judgment competency*. This competency includes the degree of alignment with certain principles and its level of integration with an individual's capacity to reason and act.

In unification of other DMN functions, Reniers and colleagues (2012) supported the notion that:

> The acceptability of the actions described in scenarios are based on the integration of information about other people's beliefs and intentions (ToM), reference to the these peoples feelings (empathy), and reflection upon one's own feelings, norms and values (self-referential mental processing). (p. 203)

Overall, Lanius and colleagues (2011) defined the DMN as a network that "aids in serving to consolidate, stabilize and set the context for future information processing" (p. 339).

The DMN's relationship to internal tasks further extends to mind wandering or daydreaming. Baars (2002) introduced the Global Workspace theory, suggesting that mind wandering really arises as input from internal and external sources attempt to gain access into the limited capacity of a central network. According to Christoff, Gordon, Smallwood, Smith, and Schooler (2009), mind wandering activates both the DMN and executive network, with activation being at its peak when an individual is not aware of the process. They have suggested that mind wandering may be understood as a mental state that supports cooperation between the two networks. In this model, DMN activation is most active in effortful introspection, whereas there are gradations of DMN and executive network activations during mind wandering and executive network functions during a task. Notably, when the mind decides to wander, it wanders to thoughts or feelings associated to self or others. Research by Killingsworth and Gilbert (2010) has revealed that human mind wandering is disposed towards negativity and that increased mind wandering is associated with lower levels of happiness.

In contrast, Smallwood and Schooler (2015) suggested that mind-wandering has also been linked to: (a) improved capacity for delayed gratification via future planning in self-generated thoughts, which itself has been predictive of positive attributes such as greater intelligence; (b) creativity or the capacity to generate novel creative thoughts, especially during simple tasks or in daily life; (c) meaning, whereby engaging in mental time travel, particularly thinking about specific remembered or anticipated events can enhance self-reported meaning in life, as meaning in personal experience fosters well-being and enhances health outcomes; and

(d) mental breaks, where mind-wandering (particularly future-oriented thoughts) has been found to reduce undesirable mood states associated with engaging in boring task

Another salient characteristic of the DMN is its involvement with other neural networks. More specifically, the DMN does not work in isolation; rather, it functions in relation to other neural networks: specifically, the Salience Network (SN) and Central Executive Network (CEN). The SN is a neural network that determines the importance of internal and external stimuli (salience) as related to an individual's context, further orienting an individual to internal activity or the environment. It is composed of the ventrolateral prefrontal cortex, anterior insula, anterior cingulate cortex (Sridharan, Levitin, & Menon, 2008), amygdala, and putamen (Patel, Spreng, Shin, & Girard, 2012). The CEN is activated when the brain is engaged in a task, and its central nodes are the dorsolateral prefrontal cortex and posterior parietal cortex (Sridharan et al., 2008). The SN has been found to be responsible for transitioning between the DMN and the CEN (Goulden et al., 2014). Anticevic and colleagues (2012) defined the DMN as a constellation of areas in the brain anti-correlated to fronto-parietal regions, further labeling the DMN as a task negative network (TNN) in contrast to a task positive network (TPN), as the DMN deactivates when one is engaged in an external task. This notion however, has been found to be incorrect, as tasks involving self and social processes have been found to activate the DMN (Mars et al., 2012).

Notably, there is a commonality underlying every function that has been associated with the DMN: namely, its underlying role as a bridge to internal reflective capacity, the capacity for which has been found to connect self and social processes. Thus, it is a network dedicated to bridging others and the self (BOATS), both experientially and functionally.

The Default Mode Network: Structure

Areas composing the DMN include the medial pre-frontal cortex (mPFC), the precuneus (Raichle et al., 2001), lateral parietal and temporal cortices (Spreng et al., 2009), and the Cingulate Cortex (primarily PCC; Buckner, Hanna, & Schacter, 2008). A more extensive list can be viewed in Figure 1.

The mPFC is a central node in the DMN, having among the highest baseline metabolic activity at rest (Gusnard, Akbudak, Shulman, & Raichle, 2001). In addition, it has dense connections to the limbic system and has been found to be involved with monitoring and modulating emotions arising from these regions. Some models suggest divisions in the mPFC that correspond to conceptual and embodied self-awareness (Lanius et al., 2011). The ventral mPFC (vmPFC) is seen as a key player for embodied self-awareness, whereas the dorsal mPFC (dmPFC) has been connected with conceptual awareness. Lanius and colleagues (2011) defined conceptual emotional awareness as a linguistic and rational process that enables reflection, interpretation, and decision-making in relation to an embodied emotion or sensation. In contrast, embodied emotional/self-awareness is intuitive; "based on sensing, feeling and acting, [it] tends to be spontaneous and creative and is usually lived in the present moment" (p. 333). In relation, Bechara, Damasio, and Damasio (2000) described the vmPFC as "a repository of dispositionally recorded linkages between factual knowledge and bioregulatory states" (p. 296). In a meta-analytic study, Etkin and Wager (2007) discovered that in relation to other anxiety disorders, diminished vmPFC activation is unique to PTSD. They also viewed the vmPFC as playing an integral role to the Somatic Marker hypothesis, which describes decision-making as a "process that is influenced by marker signals that arise in bioregulatory processes" (p. 295).

Anterior cingulate cortex (ACC) 2
Bilateral inferior parietal and posterior temporal around the temporo-parietal junction (TPJ) 5
Hippocampal formation 2, 4
Inferior parietal lobule 2, 7
Insula 7
Lateral parietal cortices 1, 4, 7
Lateral temporal lobes 7
Medial posterior cortex 5
Medial pre-frontal cortex (mPFC) 1, 2, 4, 5, 6, 7
Middle temporal gyrus 3
Posterior cingulate cortex (PCC)1, 2, 4, 5, 6
Precuneus 1, 5, 6
Thalamus 7

References
1) Bianconi et al., 2013
2) Buckner et al., 2008
3) Daniels, Bluhm, & Lanius, 2013
4) Fair et al., 2008
5) Mars et al., 2012
6) Raichle et al., 2001
7) Spreng et al., 2009

Figure 1. The Default Mode Network: Associated regions.

As a convergence zone for self and emotionally based information, decreases in vmPFC activation are indicative of irregularities in potential higher-order intuitive states. Interestingly, researchers have also associated vmPFC to self-referential cognition, and the dmPFC when forming impressions about others; however, it is “more akin to a gradient than a true functional dissociation” (Wagner et al., 2012, p. 455). It has been associated with information processing relevant to the self and considering the minds of other people (Mitchell, Banaji, & Macrae, 2005).

The parietal lobes emerged evolutionarily from the hippocampus (Cozolino, 2010), and are related to somatosensory perception, bodily perception, visual-spatial orientation, memory, symbolic synthesis, and cross-modal matching (Beaumont, 2008). As such, the parietal cortices are necessary for creating internal maps of the environment and the self in relation to the environment. The parietal lobes may well be supporting mPFC-mediated self-related processes with an imaginary self upon which to reflect.

Two studies (Buccione, Fadda, Serra, Caltagirone, & Carlesimo, 2008; Kapur, Ellison, Smith, McLellan, & Burrows, 1992) found that bilateral lesions in the temporal lobes play a significant role in memory for past events, affecting both autobiographical (i.e., episodic, semantic) and non-autobiographical (i.e., public events, general semantic knowledge) memory. In addition to the mPFC and parietal cortices, the bilateral temporal lobes appear to provide context to this formation of self.

Ablation studies have found that the anterior cingulate cortex (ACC) contributes to the brain's ability to detect and correct errors, regulating both cognitive and emotional processing (Bush, Luu, & Posner, 2000). This region, though associated to DMN functioning in some studies, has been increasingly understood as a central component in the SN. In contrast, the posterior cingulate cortex (PCC) has been implicated in evaluative functions and mediation of interactions of emotional and memory-related processes (Maddock, Garrett, & Buonocore, 2003). In conjunction with the mPFC, parietal cortices, and temporal lobes, the cingulate gyrus functions as a primer for current and future social engagement. Overall, the PCC has been related to DMN functioning in more studies, and as such will be understood as a primary node.

A meta-analytic review of studies of the precuneus suggests that activations in this region are involved in mental imagery strategies related to the self, facilitation of successful episodic memory retrieval (Cavanna & Trible, 2006), and the integration of mental images (D'Angiulli et al., 2013). In coordination with previously implicated regions, these regions provide for an autobiographically constructed process localized in the imaginal and physical world that must adapt constantly to information being received from the environment.

Table 1

The Default Mode Network: Associated Regions and Functions

Region	Function
Medial prefrontal cortex (Mitchell et al., 2005)	Information processing relevant to self and considering the minds of other people
Parietal lobes (Beaumont, 2008)	Somatosensory perception, bodily perception, visual-spatial orientation, memory, symbolic synthesis, and cross-modal matching
Temporal lobes (Buccione et al., 2008; Kapur et al., 1992)	Role in memory for past events, affecting both autobiographical (i.e., episodic, semantic) and non-autobiographical (i.e., public events, general semantic knowledge) memory.
Anterior Cingulate Cortex (Bush et al., 2000)	Detect and correct errors, regulating both cognitive and emotional processing
Posterior Cingulate Cortex (Maddock et al., 2003)	Evaluative functions and mediation of interactions of emotional and memory-related processes
Precuneus (Cavanna & Trible, 2006),	Mental imagery strategies related to the self, facilitation of successful episodic memory retrieval
Temporo-parietal Junction (Saxe, 2006)	Theory of mind, empathy

Li, Mai, and Liu (2014) conducted a meta-analysis on the DMN, encountering three main subsystems thereof: the vmPFC in the medial temporal lobe (MTL) subsystem, critically involved with processing emotional features; the anterior mPFC and PCC, responsible for the elaboration of the experiential feelings of self; and the dmPFC and the temporo-parietal junction (TPJ), central to ToM (mentalizing) and morality. The PCC was also found to be a central node involved with explicit emotional engagement, emotional word processing, face perception, implicit emotional engagement during self-directed attention or evaluation, and autobiographical memory. The role of the mPFC was found to be critical in all of the studies, supporting the simulation theory, stating that humans' social cognitive functions are contingent upon past experiences, which serve as a platform for understanding others. It was also indicated that mPFC activation increases with the complexity of tasks performed, with this complexity also manifesting in activations higher up in the frontal cortex. This finding potentially reflects a bottom-up process, where non-conscious, effortless information processing emerges into effortful cognitive processing.

Andrews-Hanna, Reidler, Sepulcre, Poulin, and Buckner (2010) yielded similar findings, encountering two distinct systems. They labeled the first subsystem the *dorsomedial prefrontal cortex subsystem*, including the dmPFC, TPJ, lateral temporal cortex, and temporal pole. The second subsystem they called the *medial temporal lobe (MTL) subsystem*, which includes the vmPFC, posterior inferior parietal lobule, retrospelenial cortex, parahippocampal cortex, and hippocampal formation. They discovered selective activation within these networks when engaging in different tasks. The dmPFC subsystem was preferentially activated when individuals were making self-referential judgments about a present situation. In contrast, the MTL was engaged during episodic judgments about personal future.

At the neuronal level, the DMN contains Von Economo Neurons or Spindle cells, which are found in the ACC, anterior insula, and areas of the prefrontal lobes. Anatomically, they are found linking each one of these areas together and also extend, connecting with the amygdala, thalamus, hypothalamus, and periaqueductal gray matter. To this day, they have only been found in large-brained social mammals (Cozolino, 2014). It is hypothesized that they are an “obligatory neuronal adaptation in very large brains, permitting fast information processing and transfer along highly specific projections and that evolved in relation to emerging social behaviors in select groups of mammals” (Butti, Sherwood, Hakeem, Allman, & Hof, 2009, p. 254). Mirror neurons have also been found in areas associated to the DMN: more specifically, the inferior frontal gyrus (Kilner, Neal, Weiskopf, Friston, & Frith, 2009) and rostral region of the right superior parietal lobule (Iacoboni et al., 1999). Mirror neurons are activated while observing another individual performing an action, and when one performs the action. In a TED talk, V. S.

Ramachandran (2009) called them "Gandhi neurons or empathy neurons" (5:56). He also discussed how mirror neurons allowed for a "Lamarckian evolution" (3:51), as they enable one to imitate and emulate others, learning a skill that would usually take years, or even generations, in a matter of minutes.

Situated in convergence zones of higher order motor, visual, and emotional processing, mirror neurons have the unique advantage of being activated during both observation and action (Cross & Iacoboni, 2013). Incorporated in these systems are blueprints of others as well as the internal maps of the spaces we inhabit. Somatic experiences, survival needs, and strategies for goal achievement are also embedded in these systems (Cozolino, 2014).

> Over the last twenty years, mirror systems have helped us to understand how our brains link together in the synchronization of such group behaviors as hunting, dancing, and emotional attunement. They are most likely involved in the learning of manual skills, the evolution of gestural communication, spoken language, group cohesion, and empathy. (Jeannerod, as cited in Cozolino, 2014, p. 147)

It would be interesting to determine whether Post-Traumatic Stress Disorder (PTSD) results in irregularities within the cytoarchitecture of one or both of these types of neurons.

The Development of the DMN

From a developmental standpoint, it is interesting to note that during infancy (up to 2 years), humans lack a sense of self. Though a self may have been developing during that time, with experiences becoming embedded into implicit memory systems, a stable and continuous sense of self capable of introspection simply does not exist during early infancy. As time goes on, the brain develops in interaction with its social environment, giving rise to a sense of self. Thus, humans "seem to emerge into self-awareness from an undifferentiated sense of membership and interrelationship with family and community" (Cozolino, 2014, p. 258).

It is estimated that self-recognition begins around the age of 2 (Rochat, 2003), which parallels the approximation of the beginning of explicit memory (Siegler, 1998). Following these milestones arises ToM, beginning at approximately 3 years of age, with representational ToM arising around 5 years of age (Saxe, 2006). Self-concept, in contrast, has been estimated to develop only around the ages of 7-8 (Leflot, Onghena, & Colpin, 2010). As self and social processes develop alongside each other, so are these experiences embedded in the DMN. These two seemingly independent constructs appear to be only separated by humans' necessity to categorize, as through the lens of the DMN, self and social processes are bound.

With this context in mind, it is interesting to note that the DMN has been found to stabilize by the ages of 9-12 (Thomason et al., 2008). Thomason and colleagues (2008) concluded that anterior-posterior integration of a 9-year-old was comparable to adult levels and that 7-9 year olds' levels remained significantly different. Through convergent structural and functional connectivity analyses, Supekar and colleagues (2010) demonstrated immature connectivity between the PCC-mPFC along the cingulum, a bundle of white matter fibers projecting from the cingulate gyrus to the entorhinal cortex1, allowing communication with the limbic system. This may be reflected in immaturity in one of the DMN's subsystems related to self-referential processing (Li et al., 2014). In some cases, they encountered non-existent to weak PCC-left MTL connectivity in second and third graders (7-9 years old). It is interesting to note that only between the ages of 8-13 do children begin to develop a mature grasp of delayed gratification. This includes the cognitive ability to inhibit arousing thoughts by employing abstract strategies to attain a greater reward in the future (Mischel, Shoda, & Rodriguez, 1992). These findings echo the growth of metacognitive capacity, allowing for the differentiation and

---

[1] Resides between the hippocampus and mPFC, highly connected to the limbic system (Lindemer, Salat, Leritz, McGlinchey, & Milberg, 2013)

development of a stable sense of self. It is possible that around the age of 7, there is an emergence and subsequent acquisition of a wider range of self and social capacities, and it is not until the age of 8 and beyond that these functions begin to take form and stabilize, which is reflected in DMN functioning.

Socio-emotional Impact of Post-Traumatic Stress Disorder

> If necessity is the mother of invention, then evolution itself has created the necessity for psychotherapy by shaping a brain that is vulnerable to a wide array of difficulties. (Cozolino, 2010, p. 305)

One diagnosis that is in dire need of further understanding in order to improve treatment is PTSD, currently characterized by intrusions, avoidance, arousal, and negative mood and cognitions (American Psychiatric Association [APA], 2013). In this context, dysfunctional interpersonal relationships have been understood as a secondary consequence of PTSD, yet many individuals with PTSD have been shown to exhibit violence (Galovsky & Lyons, 2004), abusive behaviors (Stinson, Becker, & Sales, 2008; Thomas et al., 2013), relational difficulties (Galovsky & Lyons, 2004; Maercker & Horn, 2012), and an increased chance of suicide (Stevens et al., 2013).

Similar to understanding neuroanatomical functions through brain lesions, the function of brain networks can be understood by examining how alterations in functional connectivity affect corresponding psychological processes. Given the associated functions of the DMN, significant increases and decreases in activity and connectivity within and between DMN regions may hinder an individual's ability to relate to himself/herself and others. Confluences of dysfunctional psychological processes are likely mirrored in the neural incoherence encountered in DMN studies.

Purpose and Importance of this Study

According to the National Institute of Mental Health (n.d.), 3.5% of U.S. adults suffer from PTSD, which is approximately 1.3% of the U.S population. This percentage is equivalent to around 40 million people; 36.6% of these cases are classified as severe. Such a high prevalence rate, in conjunction with difficulties in this demographic, are forcing researchers and clinicians to look beyond the confines of the *Diagnostic and Statistical Manual* (APA, 2013) for more comprehensive ways to diagnose and treat these serious and chronic consequences. This study sought to examine extant literature on PTSD and social neuroscience to determine how deficits in the DMN may contribute to post-traumatic symptomology.

Research Questions

This study focused on the following research questions:

1. What does the research literature tell us about the role of the DMN?
2. How does trauma impact DMN functioning?

Chapter 2: Methodology and Procedures

Studies were identified from seven databases: *Science Direct, Frontiers, Wiley, Google Scholar, Psych articles, Pubmed,* and *Psychinfo.* These databases were used to facilitate a comprehensive collection of empirically reviewed psychological and biomedical articles related to the field of study. Articles and texts were selected based on degree of relevancy to (a) the structure and function of the DMN, (b) the impact of PTSD on the DMN, (c) the relationship between the DMN and social functioning, and (d) the impact of PTSD on social functioning. Moreover, text selection included seminal reviews that have been recognized in the field.

Inclusion criteria for article selection were subject dependent. Literature on the DMN published from January 2001 through July 2014 was identified. Due to its formal introduction into the literature as *the Default Mode* by Raichle and colleagues in 2001, only a relatively small number of existing studies could be identified. As such, related articles within this time period were considered for this review. Within the research studies, subjects' ages ranged from college students to a geriatric demographic, with the exception of one article that tracked the development of the DMN throughout the lifespan (Fair et al., 2008)

Articles on neurobiology, PTSD, and social functioning published from January 1992 to July 2014 were identified. According to Huetell, Song, and McCarthy (2008), 1992 was the first year when studies used Blood-oxygen-level dependent (BOLD) contrasts and comparable technologies, procedures, and techniques to current fMRI studies. Selected studies focused on experiments that used human subjects.

The researcher employed a search strategy to identify independent and/or matched articles with *Post-Traumatic Stress Disorder (PTSD), the Default Mode Network (DMN), self,* *social functioning,* and *relationships* as main headings or text words embedded in abstracts. Relevant citations from studies were also included in this review.

In sum, 127 articles were used. Twenty-six articles were utilized to define and determine the structure and function of the DMN. A total of 36 research studies were identified investigating the impact of trauma on the resting state, 27 of which directly investigated PTSD and the DMN. Overall, the entire sample size consisted of an experimental group of 813 individuals either exposed to trauma or actively diagnosed with PTSD, compared with a control group of 697. Research studies particular to the DMN and PTSD resulted in an experimental group of 511 compared with a control group of 456. In conjunction, 23 studies related to DMN functions and 18 reviews on PTSD, the brain, and self/social functioning were integrated. An additional 39 supportive articles were included to provide background information on topics of review. Non-electronic sources included 11 published texts.

This study will begin by operationalizing the concept of self. It will subsequently discuss how the DMN relates to self-functions and the impact of PTSD on these processes. Successively, there will be an examination of the DMN's involvement with social processes. Methodological limitations will ensue, followed by a conclusion, clinical implications, and discussion/directions for future research.

Chapter 3: The Effects of PTSD on the Default Mode Network

Patients with PTSD are embedded in a distorted perceptual reality. Intrusions of unwanted memories, chaotic affective experiences, unmanageable impulses, and unpleasant somatic sensations all contribute to a world molded by trauma. Importantly, the manifestations of dysregulation go beyond *visible* symptoms, extending into processes of self and others. This phenomenon is most evident among individuals who have experienced attachment-based trauma as a result of chronic neglect or abuse from parents, whereby an identity forms from the relational patterns that have been sculpted into implicit neural networks through years of interactions. Biases in self and social cognition emerge, mirroring one's relationship with one's caregivers. Importantly, successive misattunements and ruptures without reconciliation may then lead to isolation, further exacerbating PTSD. But what of individuals who become diagnosed with PTSD later in life? Is it possible for traumatic experiences to become internalized and represented in such a way that they *trump* prior relational patterns, resulting in the deterioration of core systems that define the self? The answer to this question seems to lie in the DMN.

The Default Mode Network and Self

> Posteromedial cortices possibly [reflect] the background-foreground dance played by the self within the conscious mind. When we need to attend to external stimuli, our conscious mind brings the object under scrutiny into the foreground and lets the self retreat into the background. (Damasio, 2010, p. 243)

The self has long been a subject of discussion among philosophers and psychologists alike. Currently, the Oxford English Dictionary defines the self as "a person's essential being that distinguishes them from others, especially considered as the object of introspection or reflexive action" ("Self," n.d., para. 1). The father of Self Psychology, Heinz Kohut (as cited in Bromberg, 2014), defined self as the "independent center of initiative" (p. 3,038). Others, such as William James (1890/2012), believed the self to encompass everything that an individual is, as well as everything associated to them (i.e., house, yacht). Still some eastern philosophies consider the conscious self to be Maya, or an illusion (Cozolino, 2010).

The self remains a highly controversial topic. In this review, the self will be defined as the sum total of conscious and non-conscious processes in an organism. With influence from Kohut (as cited in Bromberg, 2014) and Wolf (Kohut & Wolf, 1978), the *sense of* self will be defined as the capacity to experience the process of existing with continuity and stability through time. This is an important distinction, considering that an individual's self is very different from having the capacity to sense (or become aware of) that self. This study will also follow Northoff and Bermpohl's (2004) conceptualization of self-functions, which is further divided into 12 domains. These include the following (see Table 2).

Table 2

Self-related Functions

Function	Description
Representation	Labeling of stimuli as self-referential
Monitoring	Monitoring self referential stimuli
Evaluation	Judgment of self-referential stimuli
Integration	Linkage of stimuli to the personal context
Self-Awareness	Awareness and recognition of the own face/body
Unity	Experience of self as a unit
Agency	Feeling of being causally involved in an action
Spatial Perspectivity	Location of the self in space
Ownership	Perceptions of body and environment as self-related
Mind-Reading	Covert mimicking of others mental states
Emotion	Convergence/experience of intero- and exteroceptive stimuli
Autobiographical memory	Integration of stimuli in personal context

In this conceptualization, the DMN supports all of these functions (Cozolino, 2010; Lanius et al., 2011; Mars et al., 2012; Reniers et al., 2012; Spreng et al., 2009). As such, the DMN can be understood as a network that *maintains* an internal sense of self. The emergence of this sense hinges on a reflective capacity, in addition to initial social encounters and the ability to remember one's past (i.e., autobiographical recall). As time passes, experiences are consolidated into identity (i.e., self-referential processing). Currently, it is hypothesized that self-conception is developed by a continuity of self-judgments relayed from observation and memory (Wagner et al., 2012). A natural increase in an individual's social network inevitably leads to more complex relationships. Higher order socialization (i.e., empathy) evolves with development, relaying back in the molding of identity. Humans develop a sense of morality based on their biological disposition, upbringing, psychosocial experiences, and levels of societal adjustment.

The development of a neural network dedicated to internal experience does beg the question, What is the evolutionary importance of having a sense of self? One hypothesis is that a sense of self, as reflected in the DMN, may aid in a process of differentiation and individuation in the context of a social environment. The evolutionary advantage of this process may be found in creative adaptation and the diversification of gene functioning (i.e., epigenetics). Increased reflective capacity may also facilitate the process of learning and enhance executive functioning (Taylor et al., 2012). An inability to learn from experience and engage reactively with the environment would likely be disadvantageous to survival. Understanding these benefits, two questions come to mind: (a) How does trauma impact DMN functioning? and (b) How is this reflected psychologically?

PTSD has been observed among combat veterans, survivors of sexual/physical/emotional abuse, and victims of natural disasters, accidents (i.e., car crashes), and other medical complications. It would be unjust to generalize symptomology across all subtypes; however, commonalities in patterns of negative cognition have been observed among all these populations. Such cognitions include self-blame, biased or otherwise incorrect views on the causes or consequences of a traumatic event, the belief that they are vulnerable or insufficient, and/or identification with an unalterable belief that they have changed for the worse. This consistent finding gave rise to a fourth symptom cluster, negative alterations in cognitions and mood, which emerged in the DSM-5. This new cluster, Criterion D, included symptoms C3-7 from the DSM-IV-TR with two new additions: “Persistent and exaggerated negative beliefs or expectations about oneself, others, or the world” and “Pervasive negative emotional state” (APA, 2013, p. 272).

Indeed, statements many PTSD victims endorse or report experiencing such sentiments as: “I am a bad person,” “Nothing good can happen to me,” and “I can never trust again” (Friedman, Resick, Bryant, & Brewin, 2011, p. 759): all suggestive that a core aspect of self has been threatened. These negative cognitions are often accompanied by emotions including fear, helplessness, and horror, as well as self-states of anger, guilt, and shame (Friedman et al., 2011). Put together, these psychological symptoms suggest that victims’ identity and continuity of self have been compromised.

It comes without surprise that such pervasive spirals of negative affect and cognition are mirrored in neural networks. In the context of this study, symptoms of DMN dysregulation surface as victims develop intrusive memories, extreme sensitivity to arousal, and distortions in self and social processes. The disintegration of the DMN imprisons PTSD victims within the echoes of traumatic experience, as they are unable to escape the rigidity of a disposition that was once beneficial to their survival.

Table 2 demonstrates irregularities in resting state functioning (grouped by findings) correlated with PTSD. Overall, the most salient pattern is coupling between the DMN and Salience Network (SN), with corresponding decreases in Central Executive Network (CEN) functioning. This seems to be a signature of trauma. Remarkably, this signature was also found among children (Suo et al., 2015). The relational connections amongst the processes of introspection (DMN), orientation (to environmental or internal variables, SN), and engagement on a particular task (CEN) are thus disrupted in PTSD, giving rise to a Traumatized Resting State (TRS). This merger network likely contributes to symptoms of hyperarousal, whereby traumatization results in an inherent focus on environmental threat detection (Tursich et al., 2015; Zhang et al., 2015). Functionally, the emergence of a TRS may be adaptive in a dangerous environment, as it maintains a higher level of orientation to the detection of salience as its default. Increased orientation may serve a protective factor, helping individuals become more vigilant about their surroundings in search of potential danger. Consequently, biases in detecting salient variables will likely distort an individual's self-awareness and ability to accurately monitor internal reactions. Perhaps this experience may have contributed to the emergence of the saying *sleeping with one eye open*.

Table 3

Impact of Trauma and PTSD on the Default Mode Network

Study	Demographic	Findings	Potential Implications
Patel et al. (2012)	Review (13 studies, PTSD on DMN) PTSD vs. Non-Trauma 145 = PTSD Control = 193	Reliable increases R Fusiform gyrus R Insula (SN) R Hippocampus (DMN) L Precuneus (CEN) L Amygdala (SN) L Putamen (SN) R Post-central Gyrus L Anterior Insula (SN) R Middle frontal gyrus (CEN) Reliable decreases: Left angular Gyrus (DMN) L rostral Anterior Cingulate L Precentral gyrus R Posterior Cingulate (DMN) R medial frontal gyrus (DMN) L Rostral anterior Cingulate R Precentral gyrus R Caudate (CEN) L Supramarginal gyrus (CEN) L Middle frontal gyrus (CEN)	Increased cross talk with network dedicated to internal/environmental orientation SN. Decreases in CEN dedicated to executive functions. Decreases throughout DMN. Overall dysregulation across networks. Dysregulation of core self and social functions.
Lei et al. (2015)	76 PTSD via earthquake, 76 trauma exposed	Increased centrality of nodes predominately involved in DMN and SN (including PCC, precuneus, insula, putamen, pallidum, and temporal regions)	Increased disposition towards salience detection. Dysregulation of core self and social functions.

(continued)

Study	Demographic	Findings	Potential Implications
Long et al. (2013)	17 survivors of motor vehicle accidents (MVA)	Enhanced nodal centralities in the SN and decreased centralities in the medial orbital frontal cortex.	Increased vigilance, decreased self/social processes.
Zhang et al. (2015)	20 PTSD patients (MVA) 20 healthy matched	Sig decreased network connectivity in aDMN, pDMN SN, sensory motor network and auditory network, Furthermore, increased in SN and pDMN connectivity.	Increased disposition towards salience detection. Dysregulation of core self and social functions.Heightened anxiety and hyperarousal. pDMN involved more with orienting self to space, emotion-memory, and decision making.
Dunkley et al. (2015)	21 PTSD veterans 27 trauma exposed	PTSD group had increased interconnectivity between DMN and ventral attention network and SN	Increased disposition towards salience detection. Dysregulation of core self and social functions. Heightened anxiety and hyperarousal.
Suo et al. (2015)	28 pediatric PTSD patients 26 trauma-exposed non-PTSD	Enhanced nodal centralities in DMN and SN and reduced in CEN.	Increased cross talk with network dedicated to environmental orientation SN. Decreased self/social and executive functioning.
Shang et al. (2014)	18 PTSD earthquake 20 healthy survivors	Increased and decreased functional connectivity within SN, DMN, CEN, somato-motor network (SMN), auditory network (AN) and visual network (VN)	PTSD patients showed widespread deficits in low-level perceptual and higher-order cognitive network. PTSD as a complex network based disorder
Chung et al. (2006)	23 PTSD patients 18 MVA 3 DV 2 physical assault 64 healthy controls	Increased cerebral blood flow in limbic regions and decreased blood flow in frontal gyrus, parietal, and temporal regions in comparison to the control group	Interference from SN, lack of ability to inhibit, plan and organize. Engagement in emotional reasoning.
Yan et al. (2013)	52 Veterans diagnosed with PTSD 52 control group veterans	Increased spontaneous activity in amygdala, ventral anterior cingulate cortex, insula and orbital frontal cortex, decreased activity in precuneus, DLPFC, and thalamus	Failure of frontal inhibition of amygdala. Intrusion of SN into DMN. Increased disposition towards salience detection. decreased capacity for self/social processes
Jin et al. (2014)	72 PTSD earthquake 86 Trauma exposed non-PTSD	Weaker positive connectivity between mPFC and amygdala, hippocampus, parahippocampal gyrus and rectus. As well as inferior OFC and hippocampus. PTSD patients also show stronger negative connectivity between PCC and insula. CAPS scores in PTSD patients had a negative correlation with connectivity between amygdala and mPFC.	Failure of frontal inhibition of amygdala. Intrusion of SN into DMN. Increased disposition towards salience detection. decreased capacity for self/social processes
Sripada et al. (2012)	15 returning male veterans diagnosed with PTSD 14 combat controls	Positive connectivity between amygdala and insula. Reduced connectivity between the amygdala and hippocampus.	Dissociation between intensely feared memories and the ability for autobiographical memory to contextualize and regulate them.
		Anti-correlation between the amygdala and dorsal/rostral areas of the ACC.	May contribute to flashbacks and an inability to control undesirable memories.
		Less activation and coherence in overall DMN and an increase in the activation of the SN.	Impairment in logical thinking in arousing situations. Errors and rewards may be overlooked due to the irregularities of their emotional responses
		Increased cross-network connectivity between the DMN and SN.	Increased disposition towards salience detection. decreased capacity for self/social processes.
Lui et al. (2009)	44 survivors natural disaster (earthquake 8.0) 32 control Acute - 25 days post	Decreased DMN integration, reduced temporal synchronization. Functional disconnections among the limbic-striatal and DMN. Hyperactivity in prefrontal-limbic and striatal brain systems and pre-supplementary motor area	Biases in episodic memory, emotional processing, decision-making.

(continued)

Study	Demographic	Findings	Potential Implications
Bonne et al. (2003)	28 civilian trauma (most MVA) survivors (11 with PTSD) Acute 6 months after trauma	PTSD : Regional cerebral blood flow (rCBF) higher in cerebellum and right precentral, superior temporal and fusiform gyrus. Cerebellar and extrastriate rCBF positive correlate with depression and PTSD symptoms. Cortisol level in PTSD negative correlation with medial temporal lobe perfusion. ACC perfusion and cortisol positively related to PTSD but negative in trauma survivors w/o PTSD.	Focus on survival and increased intrusions of SN, threat detection. Increased detection for error correction resulting in cortisol spike in PTSD sample.
Kemp et al. (2010)	14 victims of PTSD 15 individuals with Major Depressive Disorder (MDD) 15 healthy	Positive correlation between PTSD severity and right-frontal lateralization. Greater activity in PTSD vs. MDD in right-parietotemporal regions	Emotionality and difficulties with self-regulation
DiGangi et al. (2016)	Combat victims 22 veterans with PTSD 18 Combat Exposure 13 Control Group (healthy civilian)	Both PTSD and trauma exposed samples exhibited weaker connectivity within a network involving the precuneus, medial prefrontal cortex and right superior parietal lobule.	Biases in self-referential processes and mental strategies related to self, reduced episodic memory retrieval
Lanius et al. (2010)	11 subjects MVA Acute trauma 6-12 weeks	PTSD symptoms associated with connectivity of PCC/precuneus with perigenual ACC and right amygdala.	DMN connectivity was predictive of future PTSD symptoms. Merger of SN into self-processes Right amygdala shift.
Zhou et al. (2012)	15 PTSD victims MVA Acute 2 days post fMRI all developed PTSD	PCC negatively correlated with CAPS (Clinician Administered PTSD Scale) scores in right hippocampus, right amygdala and left superior temporal gyrus,. Strength of connectivity between PCC and bilateral amygdala, and even between bilateral amygdala predicts severity of PTSD symptoms	DMN connectivity predictive of future PTSD Symptoms. Right amygdala shift.
Bluhm et al. (2009)	17 female victims of PTSD (Chronic early-life trauma) and 15 healthy controls.	Reduced functional connectivity of PCC with precuneus, mPFC and bilateral parietal cortex in PTSD relative to controls	Disturbances in self-referential processing, and social cognition.
Qin et al. (2012)	62 victims of motor vehicle accidents with PTSD (22 victims dx with PTSD) 19 control group - Acute 2-days post traumatic incident	Trauma: decreased functional connectivity in right lingual and right middle temporal gyri and PCC. Decreased PCC and mPFC connectivity predictive of higher CAPS scores Increases in right middle temporal gyrus, insula, right medial frontal gyrus and left ACC and left inferior temporal gyrus,	Disturbances in self-referential processing, increased emotional dysregulation, reduced interoception.
Zhang et al. (2011)	10 Natural disaster victims with PTSD, 10 without	Reduced left hippocampal volume	Decreased capacity for consolidation, and hippocampus to regulate limbic activity.
Kim et al. (2012)	12 Sexual assault victims with PTSD	Reduced left hippocampal perfusion and activity	Decreased capacity for a victim of PTSD to remember details of a trauma
Bremner et al. (1997)	17 Survivors of child abuse, 17 healthy subjects	12% smaller left hippocampal volume	
Bing et al. (2013)	20 PTSD (MVA) 20 controls	Reduction volume of anterior PFC, inferior frontal gyrus, dorsal ACC, and right superior temporal gyrus in PTSD. Decrease in dorsolateral prefrontal cortical (dlPFC) activations Increased activation in the right anterior insula Positive connectivity between the insula and amygdala	Decreased volume and increased amplitude low frequency fluctuations in aPFC, and dACC were associated with PTSD severity Inability to inhibit unwanted memories Poor interoception and processing of negative emotions. Fight/flight bodily responses in an environment that no longer requires such adaptive measures.

(continued)

Study	Demographic	Findings	Potential Implications
Yin et al. (2011)	72 PTSD diagnosis 86 Non-PTSD EQ 8 months into event	Right hemisphere lateralization	Alterations in emotions and processing and integration of trauma recall
		Decreases in right insula, visual cortex, cerebellum	Aberrant encoding retrieval of episodic memory and complex verbal working memory.
		Overactivation in right frontal regions. Ventral mPFC, DLPFC.	Depression, anxiety autonomic arousal
Tursich et al. (2015)	21 victims dx with PTSD (childhood trauma)	Decreased connectivity left posterior insula and superior temporal gyrus within SN.	Increased hyperarousal symptoms
		Reduced connectivity in DMN (perigenual anterior cingulate and vmPFC). Reduced synchrony between dorsal anterior and posterior DMN components and between right CEN and ventral anterior DMN	Depersonalization/derealization
Daniels et al. (2010)	12 individuals with severe, chronic PTSD and 12 controls	During working memory task, enhanced connectivity between the PCC and right superior frontal gyrus, as well as between the mPFC and left parahippocampal gyrus.	Failure to deactivate associated DMN regions when attempting to engage in a working memory task, resulting in reduced attentional lapses and decrements in performance
Du et al. (2015)	21 survivors of earthquake, 21 healthy controls	3 weeks post-disaster: frontal-limbic-striatal and DMN had functional connectivity changes. 2 year follow-up only changes in DMN persisted despite recovery from high initial levels of anxiety	Long-term changes occur in core aspects of self-processing, cognitive and emotional functioning – independent of anxiety sx. Increase risk of PTSD development

Unfortunately, this hypervigilance becomes maladaptive in a safe environment. Generalization of salience detection likely raises the probability of fear-based responses in any situation that presents with ambiguity. Similar to the perceptual filling of the blind spot caused by the optic nerve, the brain's adaptive nature provides biased, survival-based responses that are inherently resistant to change. The result is an inability to remain calm in the presence of misinformed *anticipated* danger. This sense of impending doom prevents victims of PTSD from feeling safe enough to engage in accurate self-based processes that may very well help them to re-stabilize their DMN.

Interestingly, PTSD victims experience contradictory signals to focus on the environment during moments of introspection, with this process being reversed during moments requiring full engagement with the environment. Daniels and colleagues (2010) conducted an experiment with 12 individuals with severe, chronic PTSD and 12 controls, finding that individuals with PTSD had enhanced connectivity between the PCC and right superior frontal gyrus, as well as between the mPFC and left parahippocampal gyrus. Individuals with PTSD consistently failed to deactivate these associated DMN regions when attempting to engage in a working memory task, resulting in reduced cognitive performance. Furthermore, they reviewed three additional studies, all of which supported their conclusions, demonstrating that the inability to deactivate the DMN during tasks led to "decreased activity in task-related regions, attentional lapses and decrements in performance" (p. 264). In sum, the SN interferes with DMN functioning during moments of reflection, while the DMN becomes the source of interference during moments requiring the CEN.

In extension, a review of Table 3 demonstrates reductions in connectivity between frontal systems and the amygdala (a central subcortical structure part of the SN). This is compounded by hypoactive activity in frontal regions and hyperactive limbic activity, with a consequent decline in CEN functioning. This finding is consistent with the overall neuropsychological profile of PTSD victims. Vasterling and Brailey (2005) noted that:

> Cognitive deficits are not global but are limited to specific domains, in particular attention and memory functions. Within these domains aspects of attention and memory dependent on executive controls (inhibition, working memory, initial acquisition, freedom from sensitivity to distraction and interference) appear to be especially vulnerable in PTSD. (p. 199)

Of note, the orbitofrontal cortex is highly sensitive to abnormalities in the serotonergic and noradrenergic neurotransmitter systems. Cognitive impairment observed in emotionally neutral tasks in PTSD is thought to be associated with these former systems, which are highly involved in regulation of arousal, as it is richly connected to both the amygdala and hippocampus (Vasterling & Brailey, 2005).

It is interesting to note one study (Zhang et al., 2015) that specified increases in connectivity between the SN and posterior DMN, alongside several sensory circuits. The posterior DMN involves regions associated with orienting oneself in space, emotion-memory, and decision-making (Kilpatrick et al., 2015). This is a logical conclusion, given that the demographic was composed of motor vehicle accident (MVA) victims. Hypervigilance seems to have emerged in alignment with the specific trauma, perhaps the brain's best defense in preventing another accident.

In sum, when affected individuals are in a resting state, they maintain a focus on potential threats, and when attempting to focus on a task, they are unable to inhibit self-states reflective of threat-detection, negative cognition, and emotionality. Psychologically, this implies the preservation of a rigid and active defense mechanism that was adaptive during threatening situations, yet is no longer applicable. Importantly, this manifestation is partially accounted for and maintained by impairments in cognition. Conflicting signals between self-environment interactions may further lead to isolation and cognitive dissonance, where thoughts, feelings, and actions lead to incongruous states of being, ending with a loss of agency.

A third pattern concerns disruptions in DMN regions highly related to self-referential processing (SRP). Neuroanatomically, this includes reductions in mPFC and PCC connectivity and activation. SRP can include both explicit and implicit evaluations of oneself, or oneself in relation to other people. Johnson and colleagues (2002) defined SRP as "A collection of schemata regarding one's abilities, traits and attitudes that guides our behaviors, choices and social interactions" (p. 1,808).

Victims of PTSD often experience negatively biased SRP. Bluhm and colleagues (2012) were curious about differences between SRP in PTSD victims (n = 20) and a control group (n = 15). During an fMRI scan, individuals were asked to respond to *yes* or *no* statements regarding their own characteristics (i.e., "I am a good friend"), facts about themselves (i.e., "I am

6 feet tall"), and general facts (i.e., "Paris is the capital of France," p. 240). Not only did the PTSD group endorse more statements like "I feel like an object, not like a person," or "I feel isolated and set apart from others" (p. 243), but they also did not experience any advantage when responding to questions about themselves, responding with similar reaction times to general facts. This study replicated findings by Johnson and colleagues (2002) and contributed to the growing number of studies supporting the role of the mPFC and PCC in self-referential processing. More specifically, their results also indicate diminished mPFC response during the SRP exercise in PTSD patients relative to healthy individuals.

As mentioned previously, the mPFC is a node in the DMN and a convergence zone involved with the self-process of integration. Dysfunctions in dmPFC functioning may impact self-related cognitions and embodied self-awareness, whereas dysfunctions in vmPFC may result in distortions in impressions of others and conceptual self-awareness (dmPFC). The associations of these functions are curious in their own right. Together with increases in insular-limbic connections, victims of PTSD may develop an inherent dysregulation of self and others, compounded by distrust of emotional and somatic experiences that facilitate the guidance of actions. Not only may irregular activations potentially lead to aberrant decision-making, but they may also be linked to the high levels of alexithymia (challenges identifying emotional states) often found among PTSD victims (Lanius et al., 2011).

Along with poor representation, evaluation, and awareness, other common symptoms include emotional numbing and affective disturbances such as fear, anger, guilt, and shame. It is conceivable that disjointed self-processes and fragmented memory (e.g., flashbacks, inability to remember key features of the traumatic event; APA, 2013) can lead to a rupture in the foundations of one's sense of self. Identity becomes distorted as SRPs become increasingly negative, promoting a cycle of maladaptive patterns.

Bromberg (2001) asserted that "Self reflectiveness…allows a patient fully to exist in the moment and simultaneously perceive the self that is existing. The ability of the human mind to adaptationally limit its self-reflective capacity is the hallmark of dissociation" (p. 231). Diminishment of self-reflective capacity leads to reactive states, potentially leading to difficulties in coping and maladaptive behaviors (i.e., violent outbursts, irritability). In relation, Tursich and colleagues (2015) were curious about how DMN dysregulation related to symptoms of trauma relative to other networks. They found that reduced DMN functioning was associated with dissociative symptoms such as derealization and depersonalization, whereas SN activity was related to symptoms of hyperarousal. Of interest, reduced synchrony was found between the dorsal anterior DMN (greater involvement in self processing) and posterior DMN (greater involvement in social processing). Moreover, disequilibrium between the CEN and DMN has been associated with unaware mind-wandering (Christoff et al., 2009). Together, the emergence depersonalization or derealization seems very conceivable. This is consistent with Du and colleagues' (2015) encounter of long-term DMN incoherence, despite *resolution* of anxiety symptoms (which may be more a reflection of increased SN activity). It may be possible that dissociative symptoms are more resilient to change, as depersonalization is currently understood as a result of severe recurrent anxiety with no potential expression (Cozolino, 2014). Indeed, treatments for depersonalization and derealization have not been very effective. Perhaps the aforementioned symptoms are at their core an internetwork dysregulation.

A review by Bremner, Elzinga, Schmahl, and Vermetten (2007) noted that the most consistent findings in patients with PTSD from structural neuroimaging studies are abnormal volumes in the mPFC, anterior cingulate, and hippocampus (areas related to DMN). The reductions found in volumetric studies often imply a decreased capacity in associated functions. This study encountered right hemispheric lateralization with consistent reductions in left hippocampal volume and activity. The right hemisphere has been associated with bodily and non-verbal based experiences (Cozolino, 2010), and left hippocampal regions have been associated with context-dependent episodic or autobiographical memory (Zhang et al., 2011). In this light, right-hemisphere amygdala biased networks overwhelm left-hemispheric cortical-hippocampal networks, merging terror and fear into discriminatory and self-processes. Indeed, from a fear-conditioning model, “Extreme sympathetic arousal at the time of a traumatic event may result in the release of stress neurochemicals (including norepinephrine and epinephrine), mediating an overconsolidation of trauma memories” (Bryant, 2011, p. 254). Clinically, this correlation makes it a significant challenge for individuals to access left hemispheric biased hippocampal networks to regulate the overlearned trauma embedded in amygdala/right hemispheric biased networks (Cozolino, 2010). This process enables vague emotions to override logical decision-making, resulting in distorted emotional reasoning.

It seems that the most striking way PTSD affects autobiographical recall is through the experience of intrusions, consequently destabilizing one’s sense of agency and autonomy; however, there are also more subtle ways to detect impairment in autobiographical recall. In two studies, Moradi and colleagues (2008) found that refugees with PTSD had a reduced capacity to provide specific details from memories on an autobiographical memory test. In their other experiment, trauma-exposed cancer survivors were found to generate fewer specific semantic autobiographical details compared to controls. A negative correlation was found between symptoms and memory impairment. The lack of ability to retrieve details may result in cognitive distortions, in particular overgeneralizations, or the magnification of certain details at the expense of others. This bias may result in the skewing of facts, further reinforcing the fourth cluster of PTSD: negative mood and cognitions (APA, 2013). Lack of detail in autobiographical recall, misaligned intuitive responses, and the objectification of self may promulgate a cycle of negativity. Operating from this disposition, negativity becomes projected in social engagement, resulting in internal and external strife. Frequent failures in attunement spiral into dissociation and numbing, as the sense of self recedes into the background.

Final important details that may shed some light on PTSD are studies investigating the impact of trauma on the DMN in comparison to PTSD on the DMN. It is interesting to note that DiGangi and colleagues (2016) found reduced DMN connectivity (mPFC, precuneus, and right superior parietal lobule) in both samples of 22 veterans exposed to combat trauma with PTSD and 18 without PTSD. They concluded that trauma exposure, rather than the pathology of PTSD, may be related to DMN changes. Unfortunately, the authors did not examine what functional changes resulted from reduced DMN connectivity due to traumatic exposure. In support, six studies support changes in the DMN in acute traumatized victims (Bonne et al., 2003; Du et al., 2015; Lanius et al., 2010; Lui et al., 2009; Qin et al., 2012; Zhou et al., 2012). Of curiosity, DMN dysregulation also appears to be the most resistant to recovery in PTSD, demonstrating continual reductions 2 years post-trauma in spite of other networks recovering (Du et al., 2015). It may be that the initial rush of norepinephrine and epinephrine resulting from a traumatic event facilitates an overconsolidation of the trauma. The resultant reductions in DMN activity, may then limit self and social functioning in service of survival (Du et al., 2015). This neural event may then predispose an individual to acquire PTSD. In fact, studies have found that levels of DMN integrity may predict the severity of symptomology in PTSD patients, as well as the risk of developing PTSD (Lanius et al., 2010; Zhou et al., 2012). These are critical findings warrant further research, as they suggest potential symptomology that extends beyond *visible* symptoms.

With an understanding that simple exposure to a traumatic event can disrupt DMN functioning, it becomes logical to ask: Does exposure to trauma and the experiences leading to the development of PTSD alter DMN functioning in different ways? In the context of a temporal trajectory, it was interesting to note that despite the etiology of PTSD and timing in acute traumatized victims, findings seem to be fluidly connected across studies. Two studies examined the DMN just 2 days post MVA traumatic experience (Qin et al., 2012; Zhou et al., 2012), together of these studies encountered decreases in connectivity between the PCC and mPFC (Qin et al., 2012), PCC-bilateral amygdala, and left-right amygdala, which were additionally predictive of increased severity of PTSD symptology. Consistent findings were encountered just 3 weeks post-trauma as a result of an earthquake (Du et al., 2015), with complete functional connectivity changes in frontal-limbic-striatal and DMN networks. Surprisingly, 6-12 weeks post MVA trauma, findings were significant for increased right amygdala connectivity with PCC/Precuneus (Lanius et al., 2010). Six months post-trauma (MVA), Bonne and colleagues (2003) found continued increased blood flow to regions related to threat detection, facial expressions, and motor movements. 8 months post-earthquake with PTSD, individuals demonstrate reduced mPFC and limbic connectivity (amygdala and hippocampus), which was also negatively correlated to symptom severity. PCC and insula were also negatively correlated (Jin et al., 2014). Twenty-five days and 2 years post-trauma, reductions in DMN coherence continue, in spite of other networks recovering (Du et al., 2015). In extension, two cross-sectional studies discovered reductions in grey matter volume in regions of the DMN (insula, ACC, and mPFC) in survivors 3 years post 9/11, and increased amygdala activity in response to viewing fearful faces (Ganzel, Casey, Glover, Voss, & Temple, 2007). As such, there seems to be underlying neurobiological mechanisms giving rise to PTSD, with the DMN playing a core role.

Notably, there is convergence within the neuroanatomical findings regardless of the etiology of PTSD. There was one set of conflicting findings concerning increased (Yan et al., 2013) and decreased (Yin et al., 2011) right insular activation. Yin and colleagues (2011) examined survivors of an 8.0 magnitude earthquake in Sichuan 8 months following the natural disaster. Yan et al. (2013) examined U.S. veterans who served in Operation Enduring Freedom in Afghanistan and/or Operation Iraqi Freedom. Interestingly, Lui and colleagues (2009) examined individuals 25 days following the Wenchuan earthquake of the same magnitude (8.0), and found increases in bilateral insular activation.

These deviations may reflect inherent differences in methodology, as well as potential differences in the developmental trajectory of PTSD for different ethnicities. Another potential explanation lies in understanding that the insula is related to interoception and somatic experiences. Culturally, Asian ethnicities have a higher tendency to somaticize psychological distress (Sue & Sue, 2008). It would be interesting if this cultural disposition presented itself through DMN dysregulation and whether it unfolds differently over time. In the same context, there exist instances of delayed-onset PTSD, in particular among individuals who have sustained a traumatic brain injury. In this vein, despite an amnestic state during an accident, the reconstruction of memories may result in PTSD in and of itself (Bryant, 2011). This process of reconstruction may also influence the course of DMN functioning.

The DSM-5 categorizes symptoms in such a way that makes it more amenable to diagnose individuals: a system that confers both strengths and weaknesses. One pitfall of this method is that by creating independent constructs, it becomes easy to lose sight of how these symptoms really manifest together as a whole. This notion is played out in the TRS, which appears to play a role in symptoms of hyperarousal, avoidance, intrusions, negative mood and cognitions, and potentially beyond. Negative valences associated with self and social processes are defined by DMN connectivity with the limbic system. These conflicts are compounded by inefficient network transitions, manifesting in poorer executive functioning, attention, and working memory. Network abnormalities lead to social difficulties, leading to avoidance-based symptoms, as increased disinhibition results in a loss of control and ultimately a fragmentation of self.

From a conceptual perspective, PTSD occurring in adulthood seems to work on core systems of the self from general to specific, or from *the outside in*. More specifically, in attachment, individuals develop internal working models that generalize to their experiences of strangers. Thus, an individual who was securely attached will likely see the world as a safe place where he/she can take risks without experiencing internal conflict, if this risk were to result in failure. However, traumatic exposure, (e.g., with veterans being subjected to as well as perpetrating violence) may result in one's sense of relational safety and trust becoming obsolete, as traumatic experiences become internalized into a representation of the world characterized by distrust, shame, and guilt.

Fragmentation of Time

Perhaps one fundamental aspect of a sense of self that Northoff and Bermpohl's (2004) list did not include is temporal perceptivity. Autobiographical recall, prospection, self-reflection, and social cognition all use degrees of mental time travel. Certainly, the DMN's association with mental time travel has been documented in the literature (Østby et al., 2012). Moreover, the sense of a continuous self relies on a stable perception and experience of time. This phenomenon begs the question, Does PTSD impact one's sense of time? Are there traits that may express this distortion of time in victims of PTSD?

Literature has supported associations between impulsivity and a distorted sense of time (Berlin, Rolls, & Kischka, 2004; Rubia, Halari, Christakou, & Taylor, 2009; Wittman, Leland, Churan, & Paulus, 2007). A study by Wittman and colleagues (2011) found that cognitive time management was related to activations in the inferior frontal and medial frontal cortices, the anterior insula, as well as the inferior parietal cortex: components of the DMN. In relation, Heinz, Makin-Byrd, Blonigen, Reilly, and Timko (2015) found an association between PTSD symptom severity and aggressive behavior. In fact, they found impulsivity to be "a key mediator between trauma symptoms and aggressive behavior" (p. 59).

Wittman et al. (2011) defined impulsivity as "a pattern of unplanned actions without regard for the negative consequences that might follow" (p. 44). They further elaborated that temporal distortions are present in highly impulsive individuals. One example of this correlation is fallibility in overestimating the costs of suspending time. This deficit results in untimely reactions, a diminished capacity to endure intervals of time, and poor prospection. Ultimately, impulsivity is associated with high levels of a present orientation and a reduced ability to think in the future. More directly, the authors also suggested that several studies have shown impulsive individuals to overestimate and under-produce time intervals. Neurobiologically, the authors found increasing activation in the posterior insula during the encoding phase of their experiment. Moreover, they found that levels of activation in motor execution regions were correlated with impulsivity and behavioral performance. One theory related to this phenomenon is that the subjective experience of duration is directly related to the amount of energy expended during cognitive processing (Eagleman & Pariyadath, 2009). Others have proposed that the inherent features of time perception are intimately tied to memory (Staddon, 2005; Wackermann & Ehm, 2006).

In relation to impulsivity in PTSD, one finds higher activations in the insula and denser connections with the limbic system. Deficits in the tolerance of impulse and affect are well known traits of individuals afflicted with PTSD. This deficiency may be further exacerbated by cognitive misalignments of time estimations as well as a decreased capacity to hold potential benefits in mind for long enough due to working memory, attention, and executive-based deficits (Vasterling & Brailey, 2005).

The inability to delay gratification as a result of lack of impulse control relates to the earlier discussion of the developmental trajectory of 7-9 year olds. Irritability, reckless and self-destructive behavior, and angry outbursts are all related to, if not inclusive of, impulsivity. Indeed, Briere and Spinazzola (2005) understood these difficulties as “self-capacities,” further defining them as “dysfunction[s] in one’s abilities to regulate one’s internal experience and one’s interaction with others,” with dysfunctional behaviors resulting from this domain, including: “suicidality, impulse control, substance abuse and tension reduction behaviors” (p. 402).

Holeman (1996) suggested that individuals with PTSD experience temporal disintegration, or “a process in which the present moment becomes isolated from the continuity of past and future time” (p. xi). From this vantage point, intrusions and triggering experiences can be seen as an inability to separate past experiences from the present. In support of Holeman’s hypothesis, Holocaust survivors frequently, albeit anecdotally, reported feeling disoriented in relation to their experience of the past and present. The natural trajectory of temporal integration then becomes stymied by temporal disintegration as a result of trauma. In conjunction with

Wittman and colleagues' study (2011), the present becomes cognitively misattuned to and temporally understood out of context. In this light, the stability and continuity of self becomes threatened. In reviewing several studies, Wittman et al. concluded that "individuals become cognitively and emotionally 'stuck' in their prior traumatic experiences, and are likely to experience elevated levels of distress once it has passed" (p. 83), suggesting that "severity predicts the immediate response, which, in turn, is associated with the degree of past orientation and distress" (p. 84).

From a neurobiological perspective, reductions in precuneal activity in PTSD victims (Yan et al., 2013) may be related. The precuneus has been found to play a role in self-related mental representations and the integration of past and present information. In this context, decreased precuneal activity may be reducing an individual's access to internal resources, hindering flexibility and the ability to relate memories to the present context.

Victims of severe PTSD are dominated by past traumatic experiences and the threat of a biased imagined future, losing grasp of the present. Cognitive and emotional distortions in time promulgate decision-making that is not based in reality. The ruptured integrity of temporal experience directly impacts the continuity and stability of self. Confusion and limited metacognitive capacity lead to impulsivity, impacting relationships negatively. Self-awareness and identity become negatively biased, as the mPFC, PCC, and limbic relationships are adapted to a reality that has passed. Subjective distress is maintained and victims are unable to switch off the SN during times of self-reflection. Moreover, as they engage with the environment, they are unable to inhibit their negative cycles of self. How is it, then, that dysregulated DMN activity may lead to social impairment? Do these negative cycles get projected into the environment, or do they stay hidden in the self?

The DMN and Social Processes

The relationship between the DMN and social cognition is well documented (Laird et al., 2011; Schilbach, Eickhoff, Rotarska-Jagiela, Fink, & Vogeley, 2008). The importance of social cognitive processes is endless. They mediate attachment processes between the parent-child dynamic, promote human survival through communal living and socializing, and serve as a baseline for people to reason morally and act with beneficence. The necessity to track the complexity of our ever growing and changing social networks has become vital. The trajectory of human brain development has been suggestive of these adaptations, and can be characterized by its tendency to differentiate with increasing complexity. From the perspective of social neuroscience, scholars propose that the act of observing and imagining another person in a particular emotional state leads to an automatic reproduction of that state as it is neurally represented in the observer, thus resulting in what is called a *shared neural representation* (Singer & Lamm, 2009). Table 4 includes four social cognitive functions that Nietlisbach & Maercker (2009) consider to be important for successful social interactions. Saxe's (2006) notion of Representational ToM was included to provide further specificity and accuracy.

Table 4

Social Cognitive Functions

Social Cognition	Description
Theory of Mind (ToM; Nietlisbach & Maercker, 2009)	Cognitive; Recognizing that another has a mind and accurately assuming what that mental state is
Representational ToM (Saxe, 2006)	How a mental state is represented in the other
Empathy (Nietlisbach & Maercker, 2009)	Affective; shared emotional state via observation and imagination
Emotional Resonance (Nietlisbach & Maercker, 2009)	Non-conscious, implicit, affective resonance via non-verbal cues, social signals
Perception of social exclusion (Nietlisbach & Maercker, 2009)	Exclusion = Death; detecting rejection important for survival.

Notably, Saxe's (2006) review found that ToM and representational ToM could be understood as developmental phases2 in social cognition. Saxe suggested that evidence converges on the right TPJ as an area selectively associated with higher levels of ToM. She additionally pointed out that the PCC and medial frontal regions are recruited for overall social cognition, with the vmPFC being activated in tasks of empathy and volumetric grey matter corresponding to net social connections and mentalizing (Lewis et al., as cited in Saxe, 2006). Evidently, all the aforementioned regions are part of the DMN.

A study by Nazarov and colleagues (2014) demonstrated deficits in ToM in 51 women diagnosed with PTSD due to childhood abuse. The study involved two tasks. One task was the Reading the Mind in the Eyes Test-Revised (RMET), a computer based task commonly used in ToM investigations. Put simply, the program presents cropped photographs of eyes and the surrounding facial region. Participants are required to decipher what individuals may be feeling or thinking by choosing one in four adjectives post-presentation. Reaction times and accuracy of scores are recorded. In this experiment, PTSD victims were slower at deducting complex mental states from emotionally salient facial expressions in comparison to healthy women.

In the second task, subjects were given the Interpersonal Perception Task-15 (IPT-15). They were shown 15 1-minute videos of social interactions and then asked questions (multiple choice) regarding the particular interaction that had occurred in the videos. In this task a significant correlation was found between ToM performance, dissociation, and depressive symptoms, with increases in the aforementioned symptoms strongly associated with decreased accuracy in identification and a distorted understanding of kinship interactions. Depressive symptoms were related to decrements in identifying negative and positive mental states, whereas

[2] ToM can be seen in a 3-year-old, however representational ToM is usually only seen in a 4-5-year-old.

dissociative symptoms were related to reduced capacity to identify positive and neutral mental states. Notably, the authors emphasized that these poorer performances were related to higher levels of disengagement, memory disturbance, and identity dissociation. Indeed, women who have been abused tend to perceive family environments as less cohesive and experience greater challenges in marital functioning and attachment in adult relationships (Nazarov et al., 2014). These experiences may culminate in the perception of social exclusion, further promoting the cycle of PTSD.

These challenges in relationships extend across other victims of PTSD generalizing into different environments. PTSD has been found to increase one's risk of unemployment by 150% and marital instability by 60% (Galovsky & Lyons, 2004). In one study (Riggs, Byrne, Weathers, & Litz, 1998), 70% of veterans with significant others reported relationship distress, as opposed to 30% of veterans who were not diagnosed with PTSD. The severity of PTSD was also found to have a direct correlation to the levels of distress reported. More specifically, victims of PTSD encountered challenges with intimacy, leading to the process of separation and divorce. One of PTSD's major contributors to relational challenges is numbing (MacDonald, Chamberlain, Long, & Flett, 1999; Ray & Vanstone, 2009). Emotional expression plays a profound role in relational quality. Restricted disclosure, communication challenges, and affective blunting propagate ambiguity, leading to reduced trust, marital disarray, and detachment (Riggs et al., 1998). In addition to marital discord, parenting has also been documented as an issue among individuals diagnosed with PTSD. Harkness (1993) described reports of veterans' parenting to be controlling, overprotective, and demanding. In line with these findings, it was estimated that four out of five veteran families centered their lives around the veterans' irritability, aggressiveness, depression, and withdrawal.

These relational challenges are likely influenced by task-switching rigidity and enhanced connectivity to the SN. Two other functions that have been associated with DMN activity are the perception of facial expressions and processing of social relationships (Cozolino, 2014). As suggested by Nietlisbach and Maercker (2009), PTSD victims likely interpret social signals inaccurately and as a result base their actions on biased attempts at mind-reading. The perception of accurate social interactions requires the integration of non-verbal cues while assuming the perspectives of others. Such misalignments in interpretation will inevitably result in a reduced the capacity for emotional resonance and potential perceptions of social exclusion. Deficits in ToM and emotional resonance will consequently interrupt the capacity to experience a shared emotional state (empathy). In this context, it is not surprising that PTSD has been found to negatively impact self-awareness, intimacy, sexuality, and communication, all of which are fundamental in maintaining healthy interpersonal relationships.

Flexibility and accuracy in social cognition are contingent upon the quality of internal development, as well as the capacity for self-reflection (Lanius et al., 2011). Imagined interactions—whether future, present, or past—are rooted in their necessity to utilize mental representations from autobiographical memory (Spreng et al., 2009). The use of autobiographical memory in social cognition highlights the DMN as a strategic system that is used in social processes, such as empathy (Mars et al., 2012). These important foundational and functional relationships help explain the shared use of the DMN for both self and social processes.

Similarly, self-referential processing has been intimately tied to mentalizing. Mentalizing is “a form of mostly preconscious imaginative mental activity, namely perceiving and interpreting human behavior in terms of intentional mental states (e.g., needs, desires, feelings, beliefs, goals, purposes, reasons)” (Allen, Fonagy, & Bateman, 2008, p. 2). Areas such as the

PCC, TPJ, and medial frontal cortex have all been associated with the ability to understand and attribute mental states of others (Mars et al., 2012). The DMN's relationship with areas involved in ToM and mentalizing was further supported by Schilbach and colleagues (2008), who similarly noted their shared circuitry as a salient feature. They found that both involved the precuneus, left angular gyrus, and ACC. These areas are involved with social interactions, differentiating self and others, and action monitoring in self and others, respectively. The authors suggested that the DMN primes an individual for social cognition.

It is interesting to note that reduced activation in the mPFC can result in the experience of what Fonagy has termed *disruptive impulsion*, or *uncontained unmentalized experiences*, often characterized as an unstoppable urge to do something (Allen et al., 2008). This description is reflective of the impulsivity often observed in victims of PTSD (Heinz et al., 2015).

Jack and colleagues (2013) demonstrated that social tasks consistently activated areas of the DMN while inhibiting areas activated during mechanical reasoning (i.e., dorsal parietal and lateral prefrontal cortices, both members of a TPN). This finding supports the hypothesis that human brains appear to be neurally bound to one cognitive mode at a time. The DMN thus plays a role in figure-ground perception, temporarily suppressing analytical thinking in order to promote reflection upon self and socially-related processes or suppressing such processes in order to focus on environmental demands. They hypothesized two possibilities of this relationship:

1. It may serve to increase the effectiveness of predicting future behavior. There would be more room for error if the system used for predicting an inanimate object were used for predicting human behavior, and vice versa. Suppose one reasoned that a gun

would begin firing if it felt threatened, or conversely that individuals are just things, objects that can be destroyed without any consequence.

2. Another possibility, for which the authors show preference, is the need to distinguish between conscious moral entities and non-conscious inanimate objects. Limitations and sensitivity are required with human beings, whereas applying these same rules with inanimate objects would simply not make sense.

These arguments are very interesting from the vantage point of trauma. The TRS formed from the merger of the DMN and SN, with reductions in CEN functioning, disrupts fluid transitions from reflective/social states to task oriented states (mechanical reasoning) and vice-versa (Daniels et al., 2010). Interference within DMN-SN-CEN functioning during different contexts is likely mirrored by the blending of different cognitive modes. Indeed, it is common for victims of PTSD to endorse statements like “I feel like an object, not like a person” (Bluhm et al., 2012). Given the overlapping mapping of social and self-processes, it is likely that an objectification of self may further generalize into an objectification of others. Understandably, this may have served an adaptive function during war, where empathic attunement with *enemies* would undoubtedly be maladaptive. Life-threatening circumstances necessitate individuals to think more mechanically, rather than sensitively. This may help explain why violence and interpersonal challenges are so common with victims of PTSD. An overconsolidated and generalized psychological reaction to a dangerous environment may drastically increase the chances of insensitive behaviors in an objectively non-threatening environment. This generalization may then present as maladaptive forms of reasoning, where mechanical reasoning is used in introspective/social processes, and where aspects of social reasoning are utilized in mechanical reasoning.

Another manifestation of the disrupted neural binding of independent cognitive modes may be seen in literature supporting magical thinking and a belief in paranormal activities, both of which have been robustly correlated with a history of childhood trauma (Rogers & Lowrie, 2016). Traumatic experiences may become so painful that an individual may lose ownership and dissociate (i.e., derealization, depersonalization) and these symptoms may become so pronounced that a victim may no longer desire to live in his/her own body. This may catalyze an externalization of identity whereby identity becomes embedded in the environment (Cozolino, 2010), an example being inanimate objects acquiring a life of their own; likely projected aspects of an individual's self. Therefore, it seems that being neurally bound to one cognitive mode at a time is necessary for adaptive living: something that individuals with PTSD may likely not experience in its entirety.

Interestingly, Matthew Lieberman (2013) has argued that the overlap between social and self-processes in the DMN suggests not only that are humans interested in the social world but also that this interest is a biological disposition. Through shared circuitry, the DMN promotes cooperation, empathy, and working in groups. This would identify the DMN as a "cause, rather than a consequence, of our focus on the social world" (p. 21). In addition he has argued that "The self exists primarily as a conduit to let the social groups we are immersed in (that is, our family, our school, our country) supplement our natural impulses with socially derived impulses" (pp. 191-192). From this perspective, the hypothesis for the evolutionary emergence of the DMN would be to enhance the necessity of living in groups by promoting social harmony, as living in groups increases the potential for survival.

In support of his ideas, PTSD results in a disengagement from social affairs, decreased levels of moral sensitivity, and poorer social cognitive abilities (Lanius et al., 2011), in addition to frequent reports of interpersonal difficulties families have with returning veterans (Laffaye, Cavella, Drescher, & Rosen, 2008; Ray & Vanstone, 2009; Wilcox, 2010). Social experiences are undoubtedly important in recovery from PTSD. In fact, lack of social support is one of the highest predictors of PTSD, and has been found to develop and maintain it (Nietlisbach & Maercker, 2009). Similarly, the absence of social acknowledgment was determined to be an important factor in trauma processing and recovery, as it increased the risk of PTSD.

Moral Judgment and the DMN

Given the types of self and social activities involved with the activation of the DMN, it comes as no surprise that moral judgment was also found to activate areas of the DMN (Eslinger et al., 2009; Greene, Nystrom, Engell, Darley, & Cohen, 2004; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Moll, Eslinger, & De Oliveira-Souza, 2001; Moll, De Oliveira-Souza, Bramati, & Grafman, 2002; Moll, De Oliveira-Souza, Eslinger et al., 2002; Prehn et al., 2008; Reniers et al., 2012). Reniers and colleagues (2012) defined moral judgment as "the competency to apply moral values and principles consistently when making decisions in social situations" (p. 203). In reviewing studies conducted with veterans, Litz and colleagues (2009) discussed the impact of events that may lead to what they term *moral injury,* "Such as perpetrating, failing to prevent or bearing witness to, or learning about acts that transgress deeply held moral beliefs and expectations" (p. 700). Their focus, then, is on the potential distress caused by participation in traumatic scenarios, as opposed to negative experiences resulting from being a victim. The rupture in one's deeply held belief system progresses into inner dissonance and distress, interrupting an individual's capacity to act in accordance with his/her values. If not addressed, morally injurious behaviors may consequently lead to an internalization of guilt, resulting in shame. Litz and colleagues shared that behaviors secondary to moral injury include:

> Self-harming behaviors…alcohol and drug abuse, severe recklessness and parasuicidal behavior, self-handicapping behaviors, such as retreating in the face of success or good feelings and demoralization, which may entail confusion, bewilderment, futility, hopelessness and self-loathing…most damaging is the possibility of enduring changes in self and other beliefs that reflect regressive over-accommodation of moral violation, culpability or expectations of injustice. (p. 701)

It is fitting to note that intuitions and internal representations of personal norms and values are associated with activity from the dorsolateral prefrontal cortex (dlPFC) to the medial prefrontal cortex (mPFC). As mentioned earlier, the mPFC has dense connections with the limbic system, rendering it a higher-order integrative region associated with identity (Cozolino, 2010). Interestingly, these decreases were also found by Yan and colleagues (2013), who studied the resting states of veterans with PTSD. It is possible that increased activation in these regions is necessary during moral judgment, as it requires the recruitment of SRPs along with social cognition (Reniers et al., 2012). In conjunction with correlations between DMN and morality, mind wandering, an activity that has been associated with DMN activation, has been associated with the generation of meaning, which in and of itself has been found to support well-being and health (Smallwood & Schooler, 2015).

An integral part of human experience is the process of discovering and living a meaningful life. Morality is both internalized through early experiences and discovered with self-awareness. For some, living a life of value becomes a conscious decision, whereas others may live without ever considering the meaning systems that play a role in their everyday decisions. In light of varying dispositions, the typical reaction to morally incongruent behavior is guilt and shame. Moral injury results in the disempowerment of pre-existing value systems, increasing the chances of meaningless and chaotic experiences, and consequently resulting in the acting out of impulses. Unfortunately, it seems this inability to contain impulses promotes a cycle that reinforces a fundamental identification with shame.

This cycle is particularly relevant in aggression and violence among war veterans with PTSD, who have higher levels of aggression and violence in interpersonal settings (Riggs et al., 1998). In their review of seven studies, Riggs et al. (1998) further noted that this population viewed violence as an appropriate solution to certain conflicts, with some veterans deriving pleasure from the acts, despite the ensuing guilt. These specific impulse control-deficient behaviors along with increased psychopathic-like responses may represent a reorganization of mPFC activity (Reniers et al., 2012) and its altered relationship with the limbic system.

Overlapping self and social processes serve as a platform for moral sensitivity. Their relationship makes it natural to infer that moral injury need not come from personal perpetration of morally insensitive behaviors. Just as neural systems of social engagement (i.e., mirror neuron) enable people to learn positive and adaptive behaviors from others, it is possible that the witnessing of moral transgressions made by role models, or the mere act of being ordered by a trusted official to commit a morally incongruent behavior, may become internalized and acquired as in internal conflict. The subsequent dissonance and doubt may become reflected in DMN functioning, consequently supplementing the detrimental cycle of PTSD. Repeated acts lead to desensitization, further promulgating the disintegration of boundaries and maladaptive actions.

Chapter 4: Conclusion and Discussion

Methodological Limitations

The most salient limitation of this review is the availability of research on the DMN. Although research on PTSD is abundant, it was not until the year 2001 that the DMN was first adopted as a viable construct (Raichle et al., 2001). To compensate for the latter problem, all available journals were considered when investigating the DMN and PTSD. This choice resulted in a sacrifice of quality, as journals vary in their degree of rigor. In consideration of this challenge, it is also important to take into account that the costly usage of brain imaging often requires a thorough examination of methodological procedures. Another possible shortcoming is the relatively small sample size encountered in research including the use of brain imaging, which may threaten external validity. To obtain a more comprehensive outlook, relevant studies that examined the DMN, PTSD, and self and social functioning independently were additionally integrated as appropriate.

Another related shortcoming is that there is still a lack of consensus on specific regions that make up the DMN, SN, and CEN. Although there are recurring nodes (such as the mPFC in the DMN), there is still debate as to precise neuroanatomical correlates. This disagreement resulted in the identification of some overlapping regions between and within the DMN, SN, and CEN. In this context, interpreted patterns from brain scans should be approached with caution.

A variety of etiologies may additionally result in PTSD. One may be a victim of PTSD via a variety of traumatic incidents, including but not limited to physical abuse, sexual abuse, emotional abuse, natural disasters, or accidents. Moreover this study included ten studies from China and one from South Korea. Given the lack of overall research, inferences were drawn about overall findings. As indicated in an earlier chapter, different findings may correspond to different cultural backgrounds and manifestations of symptoms. A categorization of studies can be seen in Table 5.

Table 5

Etiological Categorization of Studies

Natural Disaster	Childhood Trauma	MVA	Veterans/Combat
Jin et al. (2014)* EQ	Tursich et al. (2015)	Zhang et al. (2015)*	Dunkley et al. (2015)
Shang et al. (2014)* EQ	Bluhm et al. (2009)	Lanius et al. (2010)	Sripada et al. (2012)
Suo et al. (2015)* EQ	Daniels et al. (2010)	Qin et al. (2012)*	DiGangi et al. (2016)
Lei et al. (2015)* EQ	Bremner et al. (1997)	Bonne et al. (2003)	Yan et al. (2013)
Du et al. (2015)* EQ		Bing et al. (2013)	
Yin et al. (2011)* EQ		Long et al. (2013)*	
Lui et al. (2009) EQ		Zhou et al. (2012)	
Zhang et al. (2011)* Coal Mine Flood Disaster Survivors		Chung et al. (2006)** 18 MVA, 3 domestic violence, 2 physical assault	

Note. Patel et al. (2012) extracted data from 13 resting state studies, integrating findings on PTSD-DMN. Integrated findings were included in the study, however independent studies were not. In addition, Kemp and colleagues (2010) did not specify etiology and as such was not included. *China, ** South Korea, EQ: Earthquake, MVA: Motor Vehicle Accident

Existing literature also indicates that individuals can develop PTSD from re-constructing events post-amnesia (Bryant, 2011) or through vicarious exposure to traumata. There is also the question of Complex PTSD. These sorts of experiences have yet to be investigated from the perspective of the DMN, and thus cannot speak for PTSD as a whole. Given the developmental state of the literature on the DMN and the difficulties in yielding *clean* results, this study integrated as much literature on the DMN as possible. In this context, it was assumed that despite differing etiologies and subjective experiences, symptomological manifestations are similar and reflected in underlying brain functioning.

Conclusion

This study explored the neurobiological and subjective sequelae of PTSD during resting state. The first research question posed was, *What does the research literature tell us about the role of the DMN?* The DMN, often known as the brain's *resting state* network, has been found to be associated with autobiographical recall, self-referential processing, prospection, social cognition, and moral sensitivity. Brain regions associated with the DMN include the mPFC, bilateral temporal and parietal lobes, PCC, insula, and precuneus. Studies reveal that the DMN plays a role in processing information and can be characterized by its unique involvement in the self and social processes. The convergence of these processes contributes to an individual's ability to experience and develop a differentiated self in the context of a social environment.

The second question posed was, *How does trauma impact DMN functioning?* DMN dysregulation has been identified as soon as two days post-traumatic exposure. Traumatic exposure results in the emergence of the SN (i.e., insula, putamen, ACC) during resting states, along with general reductions in DMN (i.e., bilateral temporoparietal, PCC, and mPFC) and CEN functioning (i.e. dorsolateral prefrontal cortex and posterior parietal cortex). This generates a traumatized resting state (TRS). The nature of this merger results in internetwork rigidity manifesting as difficulties toggling between states of self-reflection/social cognition and task orientation. These difficulties are characterized by increased DMN functioning during task orientation and an increased orientation towards detecting salience (SN activity) during introspective states. Furthermore increased dissociations between frontal networks and the limbic system may lead to more difficulty inhibiting emotional arousal. In extension, results are suggestive of hyperactive limbic system and hypoactive frontal cortical activity. Neuropsychologically, the TRS results in poorer working memory, attention, and executive functions. Furthermore, interfering activity from internetworks likely results in the manifestation of social reasoning during moments requiring analytical reasoning, and vice versa.

Reductions in volume, connectivity and activity of the DMN have been encountered long after traumatic exposure, despite stabilization of other networks (and resolution of anxiety) in victims of trauma. Furthermore, symptoms of depersonalization and derealization were associated with DMN incoherence. It is likely that the surge of neurochemicals facilitates an overconsolidation of the trauma. Dissociated and reduced hippocampal functioning may suggest an inability to re-process traumatic memories through discriminatory networks, subsequently impacting core processes of self and others.

Compromised integrity of the DMN has been found to contribute to less detailed autobiographical recall, negatively biased self-referential processing (i.e., guilt, shame), inaccurate social cognition (i.e., ToM, emotional resonance), and reduced capacity for moral judgment (i.e., moral injury). Impoverished self-functions and social processes result in interpersonal challenges. Representations of moral transgressions, negativity, and shame may all become internalized, creating a new foundation from which victims of PTSD operate.

In addition, PTSD victims experience discontinuities in time, as well as cognitive management challenges, leading to impulsivity and difficulties in accurately assessing the benefits of delayed gratification. These experiences lead to a variety of self and interpersonal difficulties, such as numbing, dissociation, marital discord, violence, and poor social relationships.

From a developmental perspective, the DMN of PTSD victims appears re-configured to resemble that of an earlier developmental stage (7-9 year old). In conjunction with other symptoms, this level of de-integration results in an increase of environmental reactivity, and diminished potential for self/social reflection and development. With all these symptoms taken together, one can assert that trauma results in DMN dysregulation. Subjectively, core aspects of social and self-related functions become fragmented and replaced by maladaptive models that function within chaotic or rigid boundaries.

Table 6

Neuropsychological Profile of DMN Dysfunction: Traumatized Resting State

Neural Functioning	Description
Reduced connectivity of mPFC and limbic regions. Hypoactivity in mPFC and hyperactivity in amygdala.	Increased emotional reactivity, aberrant self-referential processing
Increased connectivity and activation of PCC with right amygdala	Threat, survival, negative biased processing in evaluation of environment and emotion mediated memory
Decreased connectivity between PCC with precuneus, bilateral parietal cortex and mPFC	Inaccurate (biased) and decreased capacity for evaluation of self, prospection, social cognition and moral sensitivity
Reduced left hippocampal functioning	Reduced autobiographical recall (context-dependent)
Increase in right hippocampus	Memory for locations (priming for action)
Decreased activity in precuneus, mPFC and right superior parietal lobule	Reduced capacity for self-reflection and biased prospection.
Reduced connectivity with ACC with mPFC and medial temporal gyrus	Dissonance between “oops center” with self-function, social cognition and moral sensitivity
Increased Insula activity and connectivity with SN (amygdala)	Poor interoception - exaggerated bodily response
Reduced insula connectivity PCC	Interoception is dissonant with evaluative functions and emotion-mediated memory
Dissociated left and right amygdala	Left: pleasant and/or unpleasant emotions, reward system. Right: negative emotions, fear and sadness)

Overall, trauma alters large scale network functioning: SN intrusions in DMN functioning during resting state, and DMN intrusions during CEN functioning.

Clinical Implications

This review synthesized the available literature on the DMN and PTSD, providing the research community with easier access to information concerning the relationship between them. The overarching aim of this study is to improve upon current understanding of PTSD in hopes of catalyzing better treatments.

At its foundation, this review demonstrates that psychological trauma can alter brain functioning. Conversely, this understanding may serve as an opportunity to educate patients on the plastic nature of the brain. This may increase their hope for recovery, as a concerted effort to change may result in alterations of brain functioning. For example, the use of mindfulness has been found to alter DMN functioning (Brewer et al., 2011) and increase cortical thickness of right medial and superior frontal cortices and the insula (Lazar et al., 2005). In conjunction, the awareness of the DMN as an evolutionary design may help others capture the importance of introspective processes. In effect, this awareness could stimulate a greater desire for attunement to self, an easier access to an open and curious attitude, and increased sensitivity in relationships.

Education increases awareness. Teaching a patient how the DMN plays a role in PTSD may reduce their uncertainties. The DMN provides a neurobiological model to guide treatment. Knowledge of the DMN’s functions (autobiographical recall, self-reflection, social cognition, and moral sensitivity) and its subsystems (vmPFC in the MTL subsystem: processing emotional features; the anterior mPFC and PCC: elaboration and experience of self; and dmPFC and the TPJ: social cognition) provides the clinician with further guidance on treatment that is founded in biology. The seeming developmental regression of the DMN of a PTSD victim may further assist a clinician with conceptualization. More specifically, treatment may necessitate the reestablishment of connectivity between PCC-mPFC and PCC-left MTL: salient areas potentially distinguishing a PTSD victim from a non-PTSD individual (Supekar et al., 2010).

Clinically, the development of a therapeutic relationship that enables appropriate levels of integration between and within the DMN can be seen as a neurobiological goal. To the author's knowledge, there has not been any research supporting the use of medication to improve DMN integrity. In this vein, this study supports the necessity of psychotherapy in the treatment of an individual with PTSD. Narratives may assist in weaving DMN functions together, and may provide a route by which to improve upon DMN integrity. This may explain why trauma narratives are often used in treatment, along with the processing of sensations, images, feelings, and thoughts. Studies demonstrating insular-limbic connections may also increase the validity of the novel forms of therapy that emphasize the necessity to process bodily experiences associated with trauma, such as somatic experiencing or EMDR. In expansion of this concept, the added component of mindfulness meditation may assist in developing a healthy orientation to the present and a non-judgmental attitude, further promoting functional relationships within the mPFC and strengthening its descending inhibitory circuitry with the limbic system.

Furthermore, it is important to highlight the DMN as a neural network bridging (the capacity and experience of) others and the self (BOATS). Deficits in ToM, emotional resonance, and empathy will ultimately lead to maladaptive environmental expectations that can drive behavior. In this light, it is likely that the DMN mediates therapeutic phenomena such as projection, transference, and countertransference. Moreover, given the DMN's relation with mind-wandering, it is very possible that the technique of free association may provide a gateway into an individuals DMN. DMN studies thus begin grounding the aforementioned concepts in empirical science. These findings also lend further support for the use of psychodynamic and relational approaches of psychotherapy when working with PTSD.

The importance of DMN functioning and its role in PTSD stimulates a dialogue on changes in identity and biases in self/social interactions. Understanding that human neurobiology may create illusory experiences may support an individual's capacity to adopt a more exploratory approach, as opposed to an identification with such changes. Comparing how an individual related to the world in the past and how he/she currently relates to the world may facilitate a discussion that enables him/her to identify his/her traumatic experience as a representation that has infiltrated his/her pre-existing system.

From the perspective of diagnosis and triaging, social impairment should be considered a primary cluster, rather than a secondary one. In this vein, attending to relational difficulties should become a principle focus during treatment. Such attention may include educating family members as well as PTSD victims on the importance of relationships as well as the signs that may emerge naturally as PTSD runs its course. Developing methods to improve expectation management would be wise. Another important factor to consider would be the use of family and group psychotherapy in the treatment of PTSD. The social sequelae of PTSD are clearly documented in the literature, and it would be wise to consider methods that treat social challenges.

Another direct treatment technique may include the utilization of a chart or other means (such as an app) of increasing awareness of how victims of PTSD divide their time during resting states. Doing so may facilitate deeper insight, enabling individuals to act from a more informed place. Awareness of underlying processes facilitates internal stability. Moreover, this knowledge may further promote healthy practices. Especially given temporal distortions in PTSD, it may be easy for such victims to lose track of time spent invested in certain activities, thus serving as a *reality check*.

Discussion and Directions for Future Research

Overall, PTSD and DMN dysregulation have been found to involve major areas of the brain; however, the degree of their involvement and levels of connectivity have been shown to fluctuate, as noted by Patel et al. (2012). These variations may be due to environmental variables (i.e. environmental perturbation may impact DMN activity), inherent differences in individual development, the etiological variations of PTSD (i.e., vehicular accident, early abuse, natural disaster, or war), and the course of PTSD (i.e., traumatic exposure, onset, maintenance, recovery). Research has just begun to address these gaps and findings have thus far are promising (DiGangi et al., 2016; Du et al., 2015). Unfortunately, both of these studies did not systematically examine the potential psychological challenges reflected in their findings. Increasing current knowledge on DMN development over the trajectory of PTSD would be a very valuable path of research, increasing awareness in order to better treatment and potential predictive capacity.

Notably, studies have also found that levels of DMN integrity may predict the severity of symptomology in PTSD patients, as well as the risk of developing PTSD (Lanius et al., 2010; Zhou et al., 2012). Although further research is necessary, this may introduce the notion of developing of an assessment measure that reliably assesses DMN functioning. As such, understanding PTSD from the perspective of the DMN may serve as a powerful diagnostic and prognostic tool. Such an assessment measure may help gauge the quality of DMN functions. In theory, this should also reflect the level of DMN integrity, which may then be further used to help predict and plot a course of recovery.

DiGangi and colleagues (2016) study warrants further research. Although their study was fascinating, it had several limitations, including: a small sample size, the use of a correlational design, a strictly male veteran sample, and a lack of correlation between combat exposure and PTSD symptom severity (clinical and functional relevance of reduced connectivity unclear). Moreover, the data collection was completed in 2012, and as such the DSM-IV-TR criteria were used. It would be interesting to examine what functional changes resulted from reduced DMN connectivity due to traumatic exposure. Their findings (in conjunction with Du and colleagues [2015]), may indicate that DMN dysregulation results in symptomology that extends beyond current PTSD criteria, beginning with traumatic exposure. It will be beneficial for this study to be replicated while accounting for these limitations, and determine whether an individual diagnosed with PTSD can be distinguished via his/her DMN functioning. Moreover, considering results from Tursich and colleagues (2015), it would be wise if future studies investigating DMN dysregulation include measures of dissociation (especially viewing depersonalization and derealization).

Another interesting pattern encountered is the merger of the DMN and SN during resting state. The TRS is reminiscent of Baars's (2002) Global Workspace Theory, whereby competing internal and external signals result in mind wandering. The difference lies in the simultaneous activation of the CEN (directing attention and working memory) during states of unaware mind wandering (Christoff et al., 2009), as opposed to the SN in PTSD. Could DMN dysregulation be understood as disorganized mind wandering rooted in trauma? This parallel may warrant further research.

One central question of clinical utility is, How resilient to change is the DMN (and the DMN of individuals with PTSD)? Practically, this would be another highly beneficial route of research for both PTSD victims and the general public. Taylor and colleagues (2012) researched differences in DMN activity between beginner meditators and experienced meditators and found significant differences. One finding included a weaker correlation between vmPFC and dmPFC in experienced meditators, reflective of a reduction in emotional appraisal during self-referential processing, promoting acceptance of thoughts, perceptions, and feelings. Another finding is a stronger correlation between the right inferior parietal lobule and the precuneus, which the authors suggested is indicative of a reduction of self-referential thoughts and greater global attention and present moment awareness. Given the current knowledge that this neural network can be manipulated intentionally, PTSD survivors may greatly benefit from the instillation of hope. It is also interesting to note that having a healthy DMN is not so much about overall increased integration as it is about strategic levels and degrees of integration within and between the network.

One fascinating study by Kilpatrick and colleagues (2015) explored how resilient personality characteristics may be reflected in the DMN and SN and how that may differ by gender. They found that increased connectivity between SN with several brain regions, including the right anterior insula, was significantly associated with resilient personality in men and women. Sex differences were found in the extent of functional integration in regions of the anterior DMN (aDMN) and posterior DMN (pDMN), with psychologically resilient women demonstrating increased functional integration in the aDMN and men in the pDMN. They speculated that both systems play a big role in self-referential processing; however, aDMN is more involved with emotion-cognition interactions, social cognition, verbal expression related functions, and socially guided decision-making. In contrast, the pDMN was more involved in emotion-memory, internally guided decision-making in uncertainty, and visuospatial-related functions. It would be interesting to study whether proportionally modifying approaches to focus on emotion-cognition would be more effective for traumatized women overall (or emotion-memory for males).

Another interesting concept proposed by Djiksterhuis, Strick, Bos, and Nordgren (2014) may play a subtle role in PTSD victims. They proposed that the DMN partially contributes to what they call *Type 3 processing* in addition to Type 1 (unconscious, fast, associative, automatic, and effortless) and Type 2 (conscious, slow, logical, rule based, goal-directed, and effortful) processing. They view Type 3 processing it as a “conscious intermezzi” (p. 360): a form of processing that is largely unconscious, very slow, abstract, exploratory, goal dependent, and largely effortless. They specified that two conscious intrusions bring Type 3 processing to light: (a) the awareness of an unconscious goal when progress becomes difficult; and (b) when an answer to a challenging question arises while doing something completely different, also known as a *eureka moment*. They view Type 3 processing as necessary in creative problem solving and making important decisions. They did, however, specify that working memory involvement is necessary, and as such the DMN is not solely responsible for all Type 3 processing.

If this form of processing were indeed to exist as proposed, it would reveal further potential risks faced by PTSD victims: more specifically, amplifying challenges with problem solving and indicating further disconnects between conscious and unconscious modes of processing. It is interesting to note the DMN acting, once again, as a sort of bridge between two modes of processing. Inferentially speaking, one can speculate that PTSD would potentially prevent this type of processing from occurring, resulting in further challenges with prolonged creative problem solving or making important decisions. Another question of interest would be whether this process becomes distorted or simply interrupted. How would that manifest behaviorally?

Findings from studies have been consistent throughout different cultures thus far. It would be interesting if future studies investigated cultural variations in DMN functioning. Based on extant literature, it would seem that these variations would be slight. There seems to be a normative developmental trajectory in regard to the DMN and evolving self-social abilities. This trend suggests that humans are all related through this neural network. Further research in this area could include potential subtle differences in cultural adaptation to trauma and how such differences maybe reflected subjectively. Similarities and differences may then shed light on *ideal* DMN states that may be more resilient to trauma. The cognitive reserve hypothesis may also be an interesting avenue to explore in relation to DMN integrity and resilience. It would seem logical that an individual that grew up in a highly enriched environment may be able to withstand traumatic experiences better than individuals who have not had the privilege of such an environment as children.

Further along the cultural continuum, there lies a necessity for humans to construct meaning and develop a sense of individuality: a long-held Western value. Given the emergence of the self from social experiences and the subsequent layering of self and social processes, could a deeper scientific understanding of the DMN contribute to inner values? In this light, it may not be so much about finding uniqueness in independence as it is about finding individuality through being related.

From a neurobiological model, morally inconsistent behaviors made by attachment figures early in life become embedded in neural networks, resulting in the adoption of conflicting moral models. It would seem that this internalization could lead to moral injury, as conflicting signals compete. It would be also interesting to explore moral injury in the context of conflicts experienced when societal and individual values are opposed to each other.

As mentioned earlier, the dependence of self and social processes may also shed light on certain psychodynamic principles. Concepts such as projection, transference, countertransference and free association are well-known in psychodynamic theory, but have yet to be rooted in science. Understanding how the DMN may be related to such experiences will contribute greatly to psychological science.

The study of how PTSD impacts the DMN has provided a deeper understanding of the human condition. It sheds light on the nature of self, relationships, morality, and how psychological processes can be deconstructed and reconstructed through biopsychosocial experiences. The benefits thereof, evident throughout this study, extend across the domains of education, conceptualization, assessment, diagnosis, and treatment.

REFERENCES

Allen, J. G., Fonagy, P., & Bateman, A. W. (2008). *Mentalizing in clinical practice*. Arlington, VA: American Psychiatric Publishing.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Anticevic, A., Cole, M. W., Murray, J. D., Corlett, P. R., Wang, X. J., & Krystal, J. H. (2012). The role of default network deactivation in cognition and disease. *Trends in Cognitive Sciences*, *16*(12), 584-592. doi:10.1016/j.tics.2012.10.008

Andrews-Hanna, J., Reidler, J., Sepulcre, J., Pulin, R., & Buckner, R. (2010). Functional-anatomic fractionation of the brain's default network. *Neuron, 65*(4)*,* 550-562. doi:10.1016/j.neuron.2010.02.005

Baars, B. J. (2002). The conscious access hypothesis: Origins and recent evidence. *Trends in Cognitive Sciences, 6*(1), 47-52. doi:10.1016/S1364-6613(00)01819-2

Beaumont, J. (2008). *Introduction to neuropsychology* (2nd ed.). New York, NY: Guilford.

Bechara, A., Damasio, H., & Damasio, A. (2000). Emotion, decision making, and the orbitofrontal cortex. *Cerebral Cortex, 10*(3), 295-307, 1047-3211. doi:10.1093/cercor/10.3.295

Berlin, H. A., Rolls, E. T., & Kischka, U. (2004). Impulsivity, time perception, emotion and reinforcement sensitivity in patients with orbitofrontal cortex lesions. *Brain, 127*(5), 1108-1126. doi:10.1093/brain/awh135

Bianconi, E., Piovesan, A., Facchin, F., Beraudi, A., Casadei, R., Frabetti, F., . . . Canaider, S. (2013). An estimation of the number of cells in the human body. *Annals of Human Biology*, *40*(6), 463-471. doi:10.3109/03014460.2013.807878

Bing, X., Ming-guo, Q., Ye, Z., Jing-na, Z., Min, L., Han, C., . . . Han-jian, D. (2013). Alterations in the cortical thickness and the amplitude of low-frequency fluctuation in patients with post-traumatic stress disorder. *Brain Research*, *1490*, 225-232. doi:10.1016/j.brainres.2012.10.048

Bluhm, R. L., Frewen, P. A., Coupland, N. C., Densmore, M., Schore, A. N., & Lanius, R. A. (2012). Neural correlates of self-reflection in post-traumatic stress disorder. *Acta Psychiatrica Scandinavica*, *125*(3), 238-246. doi:10.1111/j.1600-0447.2011.01773.x

Bluhm, R. L., Williamson, P. C., Osuch, E. A., Frewen, P. A., Stevens, T. K., Boksman, K., . . . Lanius, R. A. (2009). Alterations in default network connectivity in posttraumatic stress disorder related to early-life trauma. *Journal of Psychiatry & Neuroscience, 34*(3), 187-194. Retrieved from http://jpn.ca/vol34-issue3/34-3-187/

Bonne, O., Gilboa, A., Louzoun, Y., Brandes, D., Yona, I., Lester, H., . . . Shalev, A. Y. (2003). Resting regional cerebral perfusion in recent posttraumatic stress disorder. *Biological Psychiatry*, *54*(10), 1077-1086. doi:10.1016/S0006-3223(03)00525-0

Bremner, J. D., Elzinga, B., Schmahl, C., & Vermetten, E. (2007). Structural and functional plasticity of the human brain in posttraumatic stress disorder. *Progress in Brain Research*, *167*, 171-186. doi:10.1016/S0079-6123(07)67012-5

Bremner, J. D., Randall, P., Vermetten, E., Staib, L., Bronen, R. A., Mazure, C., & Charney, D. S. (1997). Magnetic resonance imaging-based measurement of hippocampal volume in posttraumatic stress disorder related to childhood physical and sexual abuse: A preliminary report. *Biological Psychiatry*, *41*(1), 23-32. doi:10.1016/S0006-3223(96)00162-X

Brewer, J. A., Worhunsky, P. D., Gray, J. R., Tang, Y.-Y., Weber, J., & Kober, H. (2011). Meditation experience is associated with differences in default mode network activity and connectivity. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(50), 20254-20259. doi:10.1073/pnas.1112029108

Briere, J., & Spinazzola, J. (2005). Phenomenology and psychological assessment of complex posttraumatic states. *Journal of Traumatic Stress*, *18*(5), 401-412. doi:10.1002/jts.20048

Bromberg, P. M. (2001). *Standing in the spaces: Essays on clinical process trauma and dissociation*. London, UK: Routlege.

Bromberg, P. M. (2014). *Standing in the spaces: Essays on clinical process, trauma, and dissociation* [Kindle version]. Retrieved from Amazon.com

Broyd, S. J., Demanuele, C., Debener, S., Helps, S. K., James, C. J., & Sonuga-Barke, E. J. (2009). Default-mode brain dysfunction in mental disorders: A systematic review. *Neuroscience & Biobehavioral Reviews*, *33*(3), 279-296. doi:10.1016/j.neubiorev.2008.09.002

Bryant, R. (2011). Post-traumatic stress disorder vs. traumatic brain injury. *Dialogues in Clinical Neuroscience*, *13*(3), 251-262. Retrieved from http://www.dialogues-cns.org

Buccione, I., Fadda, L., Serra, L., Caltagirone, C., & Carlesimo, G. (2008). Retrograde episodic and semantic memory impairment correlates with side of temporal lobe damage. *Journal of the International Neuropsychological Society*, *14*(6), 1083-1094. doi:10.1017 /S1355617708080922

Buckner, R., Hanna, J., & Schacter, D. (2008). The brain's default network: Anatomy, function and relevance to disease. *Annals of the New York Academy of Sciences, 1124*(1), 1-38. doi:10.1196/annals.1440.011

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences*, *4*(6), 215-222. doi:10.1016/S1364-6613(00)01483-2

Butti, C., Sherwood, C. C., Hakeem, A. Y., Allman, J. M., & Hof, P. R. (2009). Total number and volume of Von Economo neurons in the cerebral cortex of cetaceans. *Journal of Comparative Neurology*, *515*(2), 243-259. doi:10.1002/cne.22055

Cavanna, A., & Trible, M. (2006). The precuneus: A review of its functional anatomy and behavioral correlates. *Brain, 129*(3), 564-583. doi:10.1093/brain/awl004

Christoff, K., Gordon, A. M., Smallwood, J., Smith, R., & Schooler, J. W. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. *Proceedings of the National Academy of Sciences*, *106*(21), 8719-8724. doi:10.1073/pnas.0900234106

Chung, Y. A., Kim, S. H., Chung, S. K., Chae, J. H., Yang, D. W., Sohn, H. S., & Jeong, J. (2006). Alterations in cerebral perfusion in posttraumatic stress disorder patients without re-exposure to accident-related stimuli. *Clinical Neurophysiology*, *117*(3), 637-642. doi:10.1016/j.clinph.2005.10.020

Cozolino, L. (2010). *The neuroscience of psychotherapy: Healing the social brain.* New York, NY: WW Norton & Company.

Cozolino, L. (2014). *The neuroscience of human relationships: Attachment and the developing social brain* (2nd ed.). New York, NY: WW Norton & Company.

Cross, K. A., & Iacoboni, M. (2013). Optimized neural coding? Control mechanisms in large cortical networks implemented by connectivity changes. *Human Brain Mapping*, *34*(1), 213-225. doi:10.1002/hbm.21428

D'Angiulli, A., Runge, M., Faulkner, A., Zakizadeh, J., Chan, A., & Morcos, S. (2013). Vividness of visual imagery and incidental recall of verbal cues, when phenomenological availability reflects long-term memory accessibility. *Frontiers in Psychology, 4*(1), 1-45. Retrieved from http://journal.frontiersin.org/journal/psychology

Damasio, A. (2010). *Self comes to mind: Constructing the conscious brain*. New York, NY: Vintage Books.

Daniels, J. K., Bluhm, R. L., & Lanius, R. A. (2013). Intrinsic network abnormalities in posttraumatic stress disorder: Research directions for the next decade. *Psychological Trauma: Theory, Research, Practice, and Policy*, *5*(2), 142-148. doi:10.1037/a0026946

Daniels, J. K., McFarlane, A. C., Bluhm, R. L., Moores, K. A., Clark, C. R., Shaw, M. E., . . . Lanius, R. A. (2010). Switching between executive and default mode networks in posttraumatic stress disorder: Alterations in functional connectivity. *Journal of Psychiatry and Neuroscience*, *35*(4), 258-266. doi:10.1503/jpn.090010

Du, M. Y., Liao, W., Lui, S., Huang, X. Q., Li, F., Kuang, W. H., . . . Gong, Q. Y. (2015). Altered functional connectivity in the brain default-mode network of earthquake survivors persists after 2 years despite recovery from anxiety symptoms. *Social Cognitive and Affective Neuroscience, 10*(11), 1497-1505. doi:10.1093/scan/nsv040

DiGangi, J. A., Tadayyon, A., Fitzgerald, D. A., Rabinak, C. A., Kennedy, A., Klumpp, H., . . . Phan, K. L. (2016). Reduced default mode network connectivity following combat trauma. *Neuroscience Letters, 615*, 37-43. doi:10.1016/j.neulet.2016.01.010

Djiksterhuis, A., Strick M., Bos, M., & Nordgren, L. (2014). Dual-process theories of the social mind. In J. Sherman, B. Gawronski, & Y. Trope (Eds.), *Prolonged thought: Proposing type 3 processing* (pp. 355-366). New York, NY: Guilford.

Dunkley, B. T., Doesburg, S. M., Jetly, R., Sedge, P. A., Pang, E. W., & Taylor, M. J. (2015). Characterising intra-and inter-intrinsic network synchrony in combat-related post-traumatic stress disorder. *Psychiatry Research: Neuroimaging*, *234*(2), 172-181. doi:10.1016/j.pscychresns.2015.09.002

Eagleman, D. M., & Pariyadath, V. (2009). Is subjective duration a signature of coding efficiency? *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1525), 1841-1851. doi:10.1098/rstb.2009.0026

Eslinger, P. J., Robinson-Long, M., Realmuto, J., Moll, J., De Oliveira-Souza, R., & Tovar-Moll, F. (2009). Developmental frontal lobe imaging in moral judgment: Arthur Benton's enduring influence 60 years later. *Journal of Clinical and Experimental Neuropsychology 31*(2), 158-169. doi:10.1080/13803390802298064

Etkin, A., & Wager, T. D. (2007). Functional neuroimaging of anxiety: A meta-analysis of emotional processing in PTSD, social anxiety disorder, and specific phobia. *American Journal of Psychiatry*, *164*(10), 1476-1488. doi:10.1176/appi.ajp.2007.07030504

Fair, D. A., Cohen, A. L., Dosenbach, N. U., Church, J. A., Miezin, F. M., Barch, D. M., . . . Schlaggar, B. L. (2008). The maturing architecture of the brain's default network. *Proceedings of the National Academy of Sciences*, *105*(10), 4028-4032. doi:10.1073/pnas.0800376105

Frewen, P. A., Dozois, D. J., Neufeld, R. W., Densmore, M., Stevens, T. K., & Lanius, R. A. (2011). Self-referential processing in women with PTSD: Affective and neural response. *Psychological Trauma: Theory, Research, Practice, and Policy*, *3*(4), 318-328. doi:10.1037/a0021264

Friedman, M. J., Resick, P. A., Bryant, R. A., & Brewin, C. R. (2011). Considering PTSD for DSM-5. *Depression and Anxiety*, *28*(9), 750-769. doi:10.1002/da.20767

Gallese, V. (2003). The roots of empathy: The shared manifold hypothesis and the neural basis of intersubjectivity. *Psychopathology, 36*(4), 171-180. doi:10.1159/000072786

Galovsky, T., & Lyons, J. (2004). Psychological sequelae of combat violence: A review of the impact of PTSD on the veteran's family and possible interventions. *Aggression and Violent Behavior, 9*(5), 477-501. doi:10.1016/S1359-1789(03)00045-4

Ganzel, B. L., Casey, B. J., Glover, G., Voss, H. U., & Temple, E. (2007). The aftermath of 9/11: Effect of intensity and recency of trauma on outcome. *Emotion*, *7*(2), 227-238. doi:10.1037/1528-3542.7.2.227

Greene, J. D., Nystrom, L. E., Engell, A. D., Darley, J. M., & Cohen, J. D. (2004). The neural bases of cognitive conflict and control in moral judgment. *Neuron, 44*(2)*,* 389-400. doi:10.1016/j.neuron.2004.09.027

Greene, J. D., Sommerville, R. B., Nystrom, L. E., Darley, J. M., & Cohen, J. D. (2001). An fMRI investigation of emotional engagement in moral judgment. *Science, 293*(5537), 2105-2108. doi:10.1126/science.1062872

Goulden, N., Khusnulina, A., Davis, N. J., Bracewell, R. M., Bokde, A. L., McNulty, J. P., & Mullins, P. G. (2014). The salience network is responsible for switching between the default mode network and the central executive network: Replication from DCM. *Neuroimage*, *99*, 180-190. doi:10.1016/j.neuroimage.2014.05.052

Gusnard, D., Akbudak, E., Shulman, G., & Raichle, M. (2001). Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain functioning. *Proceedings of the National Academy of Sciences, 98*(7), 4259-4264. doi:10.1073/pnas.071043098

Harkness, L. L. (1993). Transgenerational transmission of war-related trauma. In J. P. Wilson & B. Raphael (Eds.), *International handbook of traumatic stress syndromes* (pp. 635-643). New York, NY: Plenum.

Heinz, A. J., Makin-Byrd, K., Blonigen, D. M., Reilly, P., & Timko, C. (2015). Aggressive behavior among military veterans in substance use disorder treatment: The roles of posttraumatic stress and impulsivity. *Journal of Substance Abuse Treatment*, *50*, 59-66. doi:10.1016/j.jsat.2014.10.014

Herculano-Houzel, S. (2009). The human brain in numbers: A linearly scaled-up primate brain. *Frontiers in Human Neuroscience, 3*(31), 1-11. doi:10.3389/neuro.09.031.2009

Holeman, A. (1996). *Studies on the relationship between trauma and the psychological experience of time* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses. (UMI No. 9704640)

Huetell, S., Song, A., & McCarthy, G. (2008). *Functional magnetic resonance imaging* (2nd ed.). Sunderland, MA: Sinaur Associates.

Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., & Rizzolatti, G. (1999). Cortical mechanisms of human imitation. *Science*, *286*(5449), 2526-2528. doi:10.1126/science.286.5449.2526.

Jack, A. I., Dawson, A. J., Begany, K. L., Leckie, R. L., Barry, K. P., Ciccia, A. H., & Snyder, A. Z. (2013). fMRI reveals reciprocal inhibition between social and physical cognitive domains. *NeuroImage*, *66*, 385-401. doi:10.1016/j.neuroimage.2012.10.061

James, W. (2012). *The principles of psychology* (Vol. 1). Mineola, NY: Dover. (Original work published 1890)

Jin, C., Qi, R., Yin, Y., Hu, X., Duan, L., Xu, Q., . . . Gong, Q. (2014). Abnormalities in whole-brain functional connectivity observed in treatment-naive post-traumatic stress disorder patients following an earthquake. *Psychological Medicine*, *44*(9), 1927-1936. doi:10.1017/S003329171300250X

Johnson, S. C., Baxter, L. C., Wilder, L. S., Pipe, J. G., Heiserman, J. E., & Prigatano, G. P. (2002). Neural correlates of self-reflection. *Brain*, *125*(8), 1808-1814. doi:10.1093/brain/awf181

Kapur, N., Ellison, D., Smith, M. P., McLellan, D. L., & Burrows, E. H. (1992). Focal retrograde amnesia following bilateral temporal lobe pathology: A neuropsychological and magnetic resonance study. *Brain*, *115*(1), 73-85. doi:10.1093/brain/115.1.73

Kemp, A. H., Griffiths, K., Felmingham, K. L., Shankman, S. A., Drinkenburg, W., Arns, M., . . . Bryant, R. A. (2010). Disorder specificity despite comorbidity: Resting EEG alpha asymmetry in major depressive disorder and post-traumatic stress disorder. *Biological Psychology*, *85*(2), 350-354. doi:10.1016/j.biopsycho.2010.08.001

Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science*, *330*(6006), 932-932. doi:10.1126/science.1192439

Kilner, J. M., Neal, A., Weiskopf, N., Friston, K. J., & Frith, C. D. (2009). Evidence of mirror neurons in human inferior frontal gyrus. *The Journal of Neuroscience*, *29*(32), 10153-10159. doi:10.1523/JNEUROSCI.2668-09.2009

Kilpatrick, L. A., Istrin, J. J., Gupta, A., Naliboff, B. D., Tillisch, K., Labus, J. S., & Mayer, E. A. (2015). Sex commonalities and differences in the relationship between resilient personality and the intrinsic connectivity of the salience and default mode networks. *Biological Psychology*, *112*, 107-115. doi:10.1016/j.biopsycho.2015.09.010

Kim, S. Y., Chung, Y. K., Kim, B. S., Lee, S. J., Yoon, J. K., & An, Y. S. (2012). Resting cerebral glucose metabolism and perfusion patterns in women with posttraumatic stress disorder related to sexual assault. *Psychiatry Research: Neuroimaging*, *201*(3), 214-217. doi:10.1016/j.pscychresns.2011.08.007

Kohut, H., & Wolf, E. (1978). The disorders of the self and their treatment: An outline. *The International Journal of Psychoanalysis, 59*, 413-425. Retrieved from http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1745-8315

Laffaye, C., Cavella, S., Drescher, K., & Rosen, C. (2008). Relationships among PTSD symptoms, social support, and support source in veterans with chronic PTSD. *Journal of Traumatic Stress*, *21*(4), 394-401. doi:10.1002/jts.20348

Laird, A. R., Fox, P. M., Eickhoff, S. B., Turner, J. A., Ray, K. L., McKay, D. R., . . . Fox, P. T. (2011). Behavioral interpretations of intrinsic connectivity networks. *Journal of Cognitive Neuroscience*, *23*(12), 4022-4037. doi:10.1162/jocn_a_00077

Lanius, R. A., Bluhm, R. L., Coupland, N. J., Hegadoren, K. M., Rowe, B., Theberge, J., . . . Brimson, M. (2010). Default mode network connectivity as a predictor of post-traumatic stress disorder symptom severity in acutely traumatized subjects. *Acta Psychiatrica Scandinavica*, *121*(1), 33-40. doi:10.1111/j.1600-0447.2009.01391.x

Lanius, R., Bluhm, R., & Frewen, P. (2011). How understanding the neurobiology of complex post-traumatic stress disorder can inform clinical practice: A social cognitive and affective neuroscience approach. *Acta Psychiatrica Scandinavica, 124*(5), 331-348. doi:10.1111/j.1600-0447.2011.01755.x

Lazar, S. W., Kerr, C. E., Wasserman, R. H., Gray, J. R., Greve, D. N., Treadway, M. T., . . . Rauch, S. L. (2005). Meditation experience is associated with increased cortical thickness. *Neuroreport*, *16*(17), 1893-1897. doi:10.1097/01.wnr.0000186598.66243.19

Leflot, G., Onghena, P., & Colpin, H. (2010). Teacher-child interactions: Relations with children's self-concept in second grade. *Infant and Child Development*, *19*(4), 385-405. doi:10.1002/icd.672

Lezak, M., Howieson, D., Bigler, E., & Tranel, D. (2012). *Neuropsychological assessment* (5th ed.). New York, NY: Oxford University Press.

Li, W., Mai, X., & Liu, C. (2014). The default mode network and social understanding of others: What do brain connectivity studies tell us? *Frontiers in Human Neuroscience, 8*(14), 1-15. doi:10.3389/fnhum.2014.00074

Lieberman, M. (2013). *Social: Why our brains are wired to connect*. New York, NY: Crown.

Lind, G. (2008). The meaning and measurement of moral judgment competence revisited: A dual-aspect model. In D. Fasko & W. Willis (Eds.), *Contemporary philosophical and psychological perspectives on moral development and education* (pp. 185-220). Creskill, NJ: Hampton.

Lindemer, E., Salat, D., Leritz, E., McGlinchey, R., & Milberg, W. (2013) Reduced cortical thickness with increased lifetime burden of PTSD in OEF/OIF Veterans and the impact of comorbid TBI. *Neuroimage: Clinical, 2,* 601-611. doi:10.1016/j.nicl.2013.04.009

Litz, B. T., Stein, N., Delaney, E., Lebowitz, L., Nash, W. P., Silva, C., & Maguen, S. (2009). Moral injury and moral repair in war veterans: A preliminary model and intervention strategy. *Clinical Psychology Review*, *29*(8), 695-706. doi:10.1016/j.cpr.2009.07.003

Long, Z., Duan, X., Xie, B., Du, H., Li, R., Xu, Q., . . . Chen, H. (2013). Altered brain structural connectivity in post-traumatic stress disorder: A diffusion tensor imaging tractography study. *Journal of Affective Disorders*, *150*(3), 798-806. doi:10.1016/j.jad.2013.03.004

Lei, D., Li, K., Li, L., Chen, F., Huang, X., Lui, S., . . . Gong, Q. (2015). Disrupted functional brain connectome in patients with posttraumatic stress disorder. *Radiology*, *276*(3), 818-827. doi:10.1148/radiol.15141700

Lui, S., Huang, X., Chen, L., Tang, H., Zhang, T., Li, X., . . . Gong, Q. (2009). High-field MRI reveals an acute impact on brain function in survivors of the magnitude 8.0 earthquake in China. *Proceedings of the National Academy of Sciences*, *106*(36), 15412-15417. doi:10.1073/pnas.0812751106

MacDonald, C., Chamberlain, K., Long, N., & Flett, R. (1999). Posttraumatic stress disorder and interpersonal functioning in Vietnam War veterans: A mediational model. *Journal of Traumatic Stress, 12*(4), 701-707. doi:10.1023/A:1024729520686

Maddock, R., Garrett, A., & Buonocore, M. (2003). Posterior cingulate cortex activation by emotional words: fMRI evidence from a valence decision task. *Human Brain Mapping, 18*(1), 30-41. doi:10.1002/hbm.10075

Maercker, A., & Horn, A. B. (2012). A socio-interpersonal context model of PTSD: The case for environments and interpersonal processes. *Clinical Psychology and Psychotherapy*, *20*(6), 465-481. doi:10.1002/cpp.1805

Mars, R., Neubert, F., Noonan, M., Sallet, J., Toni, I., & Rushworth, M. (2012). On the relationship between the "default mode network" and the "social brain." *Frontiers in Human Neuroscience, 6*(189), 1-9. doi:10.3389/fnhum.2012.00189

Mischel, W., Shoda, Y., & Rodriguez, M. L. (1992). Delay of gratification in children. In G. Lowenstein & J. Elster (Eds.), *Choice over time* (pp. 147-164). New York, NY: Russell Sage Foundation.

Mitchell, J., Banaji, M., & Macrae, N. (2005). The link between social cognition and self-referential thought in the medial prefrontal cortex. *Journal of Cognitive Neuroscience*, *17*(8), 1306-1315. doi:10.1162/0898929055002418

Moll, J., Eslinger, P. J., & Oliveira-Souza, R. D. (2001). Frontopolar and anterior temporal cortex activation in a moral judgment task: Preliminary functional MRI results in normal subjects. *Arquivos de Neuro-psiquiatria*, *59*(3B), 657-664. doi:10.1590/S0004-282X2001000500001

Moll, J., De Oliveira-Souza, R., Bramati, I. E., & Grafman, J. (2002). Functional networks in emotional moral and nonmoral social judgments. *Neuroimage*, *16*(3), 696-703. doi:10.1006/nimg.2002.1118

Moll, J., De Oliveira-Souza, R., Eslinger, P. J., Bramati, I. E., Mourão-Miranda, J., Andreiuolo, P. A., & Pessoa, L. (2002). The neural correlates of moral sensitivity: A functional magnetic resonance imaging investigation of basic and moral emotions. *The Journal of Neuroscience*, *22*(7), 2730-2736. Retrieved from http://www.jneurosci.org

Moradi, A. R., Herlihy, J., Yasseri, G., Shahraray, M., Turner, S., & Dalgleish, T. (2008). Specificity of episodic and semantic aspects of autobiographical memory in relation to symptoms of posttraumatic stress disorder (PTSD). *Acta Psychologica*, *127*(3), 645-653. doi:10.1016/j.actpsy.2007.11.001

National Institute of Mental Health. (n.d.). *Post-traumatic stress disorder among adults*. Retrieved from http://www.nimh.nih.gov/statistics/1AD_PTSD_ADULT.shtml

Nazarov, A., Frewen, P., Parlar, M., Oremus, C., Macqueen, G., McKinnon, M., & Lanius, R. (2014). Theory of mind performance in women with posttraumatic stress disorder related to childhood abuse. *Acta Psychiatrica Scandinavica*, *129*(3), 193-201. doi:10.1111/acps.12142

Nietlisbach, G., & Maercker, A. (2009). Social cognition and interpersonal impairments in trauma survivors with PTSD. *Journal of Aggression, Maltreatment and Trauma, 18*(4), 382-402. doi:10.1080/10926770902881489

Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. *Trends in Cognitive Sciences, 8*(3), 102-107. doi:10.1016/j.tics.2004.01.004

Østby, Y., Walhovd, K. B., Tamnes, C. K., Grydeland, H., Westlye, L. T., & Fjell, A. M. (2012). Mental time travel and default-mode network functional connectivity in the developing brain. *Proceedings of the National Academy of Sciences*, *109*(42), 16800-16804. doi:10.1073/pnas.1210627109

Patel, R., Spreng, N., Shin, L., & Girard, T. (2012). Neurocircuitry models of posttraumatic stress disorder and beyond: A meta-analysis of functional neuroimaging studies. *Neuroscience and Biobehavioral Reviews, 36*(9), 2130-2142. doi:10.1016/j.neubiorev.2012.06.003

Prehn, K., Wartenburger, I., Mériau, K., Scheibe, C., Goodenough, O. R., Villringer, A., . . . Heekeren, H. R. (2008). Individual differences in moral judgment competence influence neural correlates of socio-normative judgments. *Social Cognitive and Affective Neuroscience*, *3*(1), 33-46. doi:10.1093/scan/nsm037

Qin, L., Wang, Z., Sun, Y. W., Wan, J. Q., Su, S. S., Zhou, Y., & Xu, J. R. (2012). A preliminary study of alterations in default network connectivity in post-traumatic stress disorder patients following recent trauma. *Brain Research*, *1484*, 50-56. doi:10.1016/j.brainres.2012.09.029

Raichle, M. E. (2010). The brain’s dark energy. *Scientific American*, *302*(3), 44-49. doi:10.1038/scientificamerican0310-44

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences*, *98*(2), 676-682. doi:10.1073/pnas.98.2.676

Ramachandran, V. S. (2009, November). *The neurons that shaped civilization* [Video file]. Retrieved from http://www.ted.com/talks /vs_ramachandran_the_neurons_that_shaped_civilization

Ray, S., & Vanstone, M. (2009). The impact of PTSD on veterans' family relationships: An interpretative phenomenological inquiry. *International Journal of Nursing Studies, 46* 838-847. doi:10.1016/j.ijnurstu.2009.01.002

Reniers, R. L., Corcoran, R., Völlm, B. A., Mashru, A., Howard, R., & Liddle, P. F. (2012). Moral decision-making, ToM, empathy and the default mode network. *Biological Psychology*, *90*(3), 202-210. doi:10.1016/j.biopsycho.2012.03.009

Riggs, D. S., Byrne, C. A., Weathers, F. W., & Litz, B. T. (1998). The quality of the intimate relationships of male Vietnam veterans: Problems associated with posttraumatic stress disorder. *Journal of Traumatic Stress, 11,* 87-101. doi:10.1023/A:1024409200155

Rochat, P. (2003). First levels of self-awareness as they unfold early in life. *Consciousness and Cognition, 12*(4), 717-731. doi:10.1016/S1053-8100(03)00081-3

Rogers, P., & Lowrie, E. (2016). Varieties of childhood maltreatment as predictors of adult paranormality and New Age Orientation. *Personality and Individual Differences, 92,* 37-45. doi:10.1016/j.paid.2015.12.019

Rubia, K., Halari, R., Christakou, A., & Taylor, E. (2009). Impulsiveness as a timing disturbance: Neurocognitive abnormalities in attention-deficit hyperactivity disorder during temporal processes and normalization with methylphenidate. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1525), 1919-1931. doi:10.1098/rstb.2009.0014

Saxe, R. (2006). Why and how to study theory of mind with fMRI. *Brain Research, 1079*(1), 57-65. doi:10.1016/j.brainres.2006.01.001

Schilbach, L., Eickhoff, S. B., Rotarska-Jagiela, A., Fink, G. R., & Vogeley, K. (2008). Minds at rest? Social cognition as the default mode of cognizing and its putative relationship to the "default system" of the brain. *Consciousness and Cognition*, *17*(2), 457-467. doi:10.1016/j.concog.2008.03.013

Self. (n.d.). In *Oxford Dictionary Online*. Retrieved from http://www.merriam-webster.com/dictionary/self

Shang, J., Lui, S., Meng, Y., Zhu, H., Qiu, C., Gong, Q., . . . Zhang, W. (2014). Alterations in low-level perceptual networks related to clinical severity in PTSD after an earthquake: A resting-state fMRI study. *PLOS ONE*, *9*(5), e96834. doi:10.1371/journal.pone.0096834

Siegler, R. S. (1998). *Children's thinking* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Singer, T., & Lamm, C. (2009). The social neuroscience of empathy. *Annals of the New York Academy of Sciences*, *1156*(1), 81-96. doi:10.1111/j.1749-6632.2009.04418.x

Smallwood, J., & Schooler, J. W. (2015). The science of mind wandering: Empirically navigating the stream of consciousness. *Annual Review of Psychology*, *66*, 487-518. doi:10.1146/annurev-psych-010814-015331

Sonuga-Barke, E. J. S., & Castellanos, F. X. (2007). Spontaneous attentional fluctuations in impaired states and pathological conditions: A neurobiological hypothesis. *Neuroscience and Biobehavioral Reviews, 31*(7)*,* 977-986. doi:10.1016/j.neubiorev.2007.02.005

Spreng, R. N., & Grady, C. L. (2010). Patterns of brain activity supporting autobiographical memory, prospection, and theory of mind, and their relationship to the default mode network. *Journal of Cognitive Neuroscience*, *22*(6), 1112-1123. doi:10.1162/jocn.2009.21282

Spreng, R. N., Mar, R. A., & Kim, A. S. (2009). The common neural basis of autobiographical memory, prospection, navigation, theory of mind, and the default mode: A quantitative meta-analysis. *Journal of Cognitive Neuroscience*, *21*(3), 489-510. doi:10.1162 /jocn.2008.21029

Sripada, R. K., King, A. P., Welsh, R. C., Garfinkel, S. N., Wang, X., Sripada, C. S., & Liberzon, I. (2012). Neural dysregulation in posttraumatic stress disorder: Evidence for disrupted equilibrium between salience and default mode brain networks. *Psychosomatic Medicine*, *74*(9), 904-911. doi:10.1097/PSY.0b013e318273bf33

Sridharan, D., Levitin, D. J., & Menon, V. (2008). A critical role for the right fronto-insular cortex in switching between central-executive and default-mode networks. *Proceedings of the National Academy of Sciences*, *105*(34), 12569-12574. doi:10.1073/pnas.0800005105

Staddon, J. E. R. (2005). Interval timing: Memory, not a clock. *Trends in Cognitive Sciences*, *9*(7), 312-314. doi:10.1016/j.tics.2005.05.013

Stevens, D., Wilcox, H. C., MacKinnon, D. F., Mondimore, F. M., Schweizer, B., Jancic, D., . . . Potash, J. B. (2013). Posttraumatic stress disorder increases risk for suicide attempt in adults with recurrent major depression. *Depression and Anxiety*, *30*(10), 940-946. doi:10.1002/da.22160

Stinson, J. D., Becker, J. V., & Sales, B. D. (2008). Self-regulation and the etiology of sexual deviance: Evaluating causal theory. *Violence and Victims, 23*(1), 35-51. doi:10.1891/0886-6708.23.1.35

Sue, D. W., & Sue, D. (2008). *Counseling the culturally diverse: Theory and practice* (5th ed.). Hoboken, NJ: John Wiley & Sons.

Suo, X., Lei, D., Li, K., Chen, F., Li, F., Li, L., . . . Gong, Q. (2015). Disrupted brain network topology in pediatric posttraumatic stress disorder: A resting-state fMRI study. *Human Brain Mapping*, *36*(9), 3677-3686. doi:10.1002/hbm.22871

Supekar, K., Uddin, L. Q., Prater, K., Amin, H., Greicius, M. D., & Menon, V. (2010). Development of functional and structural connectivity within the default mode network in young children. *Neuroimage*, *52*(1), 290-301. doi:10.1016/j.neuroimage.2010.04.009

Taylor, V. A., Daneault, V., Grant, J., Scavone, G., Breton, E., Roffe-Vidal, S., . . . Beauregard, M. (2012). Impact of meditation training on the default mode network during a restful state. *Social, Cognitive and Affective Neuroscience, 8*(1), 4-14. doi:10.1093/scan/nsr087

Thomas, S. P., Phillips, K., Carlson, K., Shieh, E., Kirkwood, E., Cabage, L., & Worley, J. (2013). Childhood experiences of perpetrators of child sexual abuse. *Perspectives in Psychiatric Care*, *49*(3), 187-201. doi:10.1111/j.1744-6163.2012.00349

Thomason, M. E., Chang, C. E., Glover, G. H., Gabrieli, J. D. E., Greicius, M. D., & Gotlib, I. H. (2008). Default-mode function and task-induced deactivation have overlapping brain substrates in children. *NeuroImage, 41*(4), 493-503. doi:10.1016/j.neuroimage.2008.03.029

Tursich, M., Ros, T., Frewen, P. A., Kluetsch, R. C., Calhoun, V. D., & Lanius, R. A. (2015). Distinct intrinsic network connectivity patterns of post-traumatic stress disorder symptom clusters. *Acta Psychiatrica Scandinavica*, *132*(1), 29-38. doi:10.1111/acps.12387

Vasterling, J., & Brailey, K. (2005). Neuropsychological findings in adults with PTSD. In J. Vasterling & C. Brewing (Eds.), *Neuropsychology of PTSD* (pp. 178-207). New York, NY: Guilford.

Wackermann, J., & Ehm, W. (2006). The dual klepsydra model of internal time representation and time reproduction. *Journal of Theoretical Biology*, *239*(4), 482-493. doi:10.1016/j.jtbi.2005.08.024

Wagner, D., Haxby, J., & Heatherton, T. (2012). The representation of self and person knowledge in the medial prefrontal cortex. *Advanced Review, 3*(4)*,* 451-470. doi:10.1002/wcs.1183

Wilcox, S. (2010). Social relationships and PTSD symptomatology in combat veterans. *Psychological Trauma: Theory, Research, Practice, and Policy*, *2*(3), 175-182. doi:10.1037/a0019062

Wittman, M., Leland, D. S., Churan, J., & Paulus, M. P. (2007). Impaired time perception and motor timing in stimulant-dependent subjects. *Drug and Alcohol Dependence*, *90*(2), 183-192. doi:10.1016/j.drugalcdep.2007.03.005

Wittman, M., Simmons, A., Flagan T., Lane, S., Wackerman, J., & Paulus, M. (2011). Neural substrates of time perception and impulsivity. *Brain Research, 1406*, 43-58. doi:10.1016/j.brainres.2011.06.048

World Health Organization. (2004). Prevalence, severity, and unmet need for treatment of mental disorders in the World Health Organization World Mental Health Surveys. *Journal of American Medical Association, 291*(21), 2581-2590. doi:10.1001/jama.291.21.2581

Yan, X., Brown, A. D., Lazar, M., Cressman, V. L., Henn-Haase, C., Neylan, T. C., . . . Marmar, C. R. (2013). Spontaneous brain activity in combat related PTSD. *Neuroscience Letters*, *547*, 1-5. doi:10.1016/j.neulet.2013.04.032

Yin, Y., Jin, C., Hu, X., Duan, L., Li, Z., Song, M., . . . Li, L. (2011). Altered resting-state functional connectivity of thalamus in earthquake-induced posttraumatic stress disorder: A functional magnetic resonance imaging study. *Brain Research*, *1411*, 98-107. doi:10.1016/j.brainres.2011.07.016

Zhang, Y., Liu, F., Chen, H., Li, M., Duan, X., Xie, B., & Chen, H. (2015). Intranetwork and internetwork functional connectivity alterations in post-traumatic stress disorder. *Journal of Affective Disorders*, *187*, 114-121. doi:10.1016/j.jad.2015.08.043

Zhang, J., Tan, Q., Yin, H., Zhang, X., Huan, Y., Tang, L., . . . Li, L. (2011). Decreased gray matter volume in the left hippocampus and bilateral calcarine cortex in coal mine flood disaster survivors with recent onset PTSD. *Psychiatry Research: Neuroimaging*, *192*(2), 84-90. doi:10.1016/j.pscychresns.2010.09.001

Zhou, Y., Wang, Z., Wan, J. Q., Sun, Y. W., Su, S. S., Ding, W. N., & Xu, J. R. (2012). Early altered resting-state functional connectivity predicts the severity of post-traumatic stress disorder symptoms in acutely traumatized subjects. *PLOS ONE, 7*(10), e46833. doi:10.1371/journal.pone.0046833

APPENDIX A

IRB Review Letter

PEPPERDINE UNIVERSITY

Graduate & Professional Schools Institutional Review Board

April 19, 2016

Project Title: The Fragmentation of Self and Others: The Role of the Default Mode Network in Post-Traumatic Stress Disorder
Re: Research Study Not Subject to IRB Review

Dear Mr. Chan:

Thank you for submitting your application, *The Fragmentation of Self and Others: The Role of the Default Mode Network in Post-Traumatic Stress Disorder*, to Pepperdine University's Graduate and Professional Schools Institutional Review Board (GPS IRB). After thorough review of your documents you have submitted, the GPS IRB has determined that your research is **not** subject to review because as you stated in your application your dissertation ***research*** study is a "critical review of the literature" and does not involve interaction with human subjects. If your dissertation research study is modified and thus involves interactions with human subjects it is at that time you will be required to submit an IRB application.

Should you have additional questions, please contact the Kevin Collins Manager of Institutional Review Board (IRB) at 310-568-2305 or via email at kevin.collins@pepperdine.edu or Dr. Judy Ho, Faculty Chair of GPS IRB at gpsirb@pepperdine.edu. On behalf of the GPS IRB, I wish you continued success in this scholarly pursuit.

Sincerely,

Judy Ho, Ph. D., ABPP, CFMHE
Chair, Graduate and Professional Schools IRB

cc: Dr. Lee Kats, Vice Provost for Research and Strategic Initiatives
Mr. Brett Leach, Compliance Attorney
Dr. Lou Cozolino, Faculty Advisor