EXAMINATION OF NEUROPSYCHOLOGICAL MODELS AND INTERVENTIONS ASSOCIATED WITH TRAUMA

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INTRODUCTION AND QUALIFICATION

I am a Christ follower who happens to be a clinical neuropsychologist with research interests in electrophysiology, emotion regulation, decision making, and sleep. The personal context for this article stems from my training background and current clinical activities. It is important to qualify the framework of my perspective and I have provided some details about my background for the sole purpose of providing context for my evaluation and recommendations throughout the article. This provision of these details should not be taken as a proclamation of superiority in comparison to any others who provide counsel or guidance to the population of interest in this manuscript.

My training background includes initial broad training as a clinical psychologist with subsequent specialty training and board certification in clinical neuropsychology by the American Board of Professional Psychology. I am also board certified in behavioral sleep medicine by the Board of Behavioral Sleep Medicine. My clinical training and current clinical practice encompasses diagnostic and intervention services for a wide range of conditions including psychological and physiological trauma for inpatients and outpatients. I provide inpatient consultation services for a large regional hospital. These services are provided within emergency room, ICU, rehabilitation, neurology and general surgery as well as behavioral health settings. Though not an exhaustive list,

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these services include evaluation and short-term management of a wide variety of conditions including gunshot wounds, mutilation injuries, traumatic brain injury, spinal cord injuries, physical and sexual assault, other trauma-related conditions, delirium, and neurodegenerative diseases. My outpatient services include diagnostic evaluation of various psychological and neuropsychological conditions such as traumatic brain injury, neurodegenerative diseases, and differential diagnosis of TBI versus PTSD.

I do not consider myself a biblical counselor and do not possess the expertise required for biblical counseling. However, I am informed about principles of biblical counseling as well as the interface between neuroscience and biblical counselors among individuals who seek counsel. The counseling fields are now inundated with neuropsychological and neurophysiological models that purport to explain behavior, emotion, and thought. These models can provide some utility of explanation and conceptualization. However, they are often overly mechanistic and fail to account for the complexity of human behavior as well as surrounding environmental context. The purpose of this paper is to describe two relevant and popular models that are associated with trauma research in general: the dual pathway model and Polyvagal Theory. This list is not meant to be exhaustive, as there are many relevant models to choose from. Likewise, the discussion is primarily limited to neuroanatomical systems (one could also focus on neurochemistry, detailed neurophysiology or other aspects of neuroscience). Within these descriptions, utility and appropriate cautions are provided.

Trauma-related interventions are now abundant and stem in part from the described models. There are now many trauma-related interventions available for clinicians to select from, some of which stem from neuroscience and psychological research. Two of these interventions, with associated strengths and weaknesses, are discussed. A series of guidelines for evaluation of the literature is provided. Last, suggestions for how to conceptualize the neuropsychological literature as an aide in counseling are provided. This paper is qualified in the sense that it is not meant to be a formal research manuscript and is also not meant to serve as a systematic review paper or meta-analysis. If knowledge of neuroscience as applied to human behavior is desired, I encourage readers to seek out original source articles as well as completion of relevant coursework.

THE CORE ISSUE WHEN UTILIZING MODELS IN NEUROSCIENCE

There is not a week that goes by without receiving literature in the mail or email that makes sensationalized claims of remarkable results following various intervention techniques that are implemented among individuals who have sustained trauma or stress. Inherent within such claims is the utilization of such phrases as "rewire your brain," or "reclaim your brain." The providers of such techniques often link these claims to neuropsychological models (or anatomical structures and systems described therein)[44] with the intimation that such models are causal or somehow "responsible" for the various symptoms that are connected to trauma or excessive stress. Such claims are inherently attractive and popular. Likewise, some of the intervention techniques have clinical utility, while others may not. What then are we to think about these connections between neuroscience and intervention, as applied to trauma and stress?

Within the context of this paper, the purpose of neuropsychological and neurophysiological models is to provide explanatory and predictive power as applied to individual differences in human behavior, with the additional hope of informing interventions when human behavior is maligned. These models provide a scientific framework for understanding, and the goal is to explain as much of the variance in behavior as possible. For the sake of simplicity, suppose we are trying to explain the behavior of a patient who experiences extreme fear every time the home doorbell rings. Let us also suppose that we could have a real time continuous recording of amygdala activity of this person. We observe that the increase of amygdala activity is proportional to the severity of the fear response of this individual and conclude that the amygdala activity is somehow related to the severity of the fear response. Thus, we could presumably predict that the fear response originates with amygdala activity alone, as they seemingly map in a one-to-one relationship. However, what if we then observe that the fear response doesn't appear with other doorbells at other homes? This would suggest that the relationship is more complicated than first assumed, and that there are other variables involved. Such is the relationship between neuropsychological models and other variables that we

[44] Anatomical structures and systems refer to parts of the brain and how the parts are interconnected.

are attempting to explain. To date, within the field of neuropsychology and broader aspects of neuroscience, there is no single model that can account for 100% of human behavior.

The science behind such models is based on empirical study and experimental design but scientists must also attempt to define theories, laws, and universal principles which are then tested with additional empirical study.[45] Within science, the assertions made must also be falsifiable, and better research typically offers alternative explanations as well as limitations of study. Good research is typically humble, and within this context, scientists freely offer the limitations and may sacrifice quantity and scope of explanation in favor of the quality of narrow scope.

Dual Pathway Model

It is generally understood that the amygdala, which is a small group of nuclei (represented bilaterally), is an important brain region for rapid detection of emotional information. One example that I typically use in the classroom is my experience in hiking on the Appalachian Trail. I distinctly recall taking a switchback trail early in the morning and instinctively froze when I almost stepped on a rattlesnake. Upon further examination, I realized that this was not a snake, but a circular stick that resembled a coiled and venomous threat. This type of processing is also known as "bottom-up processing" in the sense that it is not overly evaluative or dependent on cortical processing (which is considered more in depth). However, it does happen rapidly, which is likely beneficial in this case as it serves as a protective mechanism. Earlier research observations among monkeys where the amygdala was removed noted that the monkeys no longer displayed fear responses to things that they were previously afraid of.[46] Likewise, case studies among humans with damage to the amygdaloid complex have difficulty detecting aversive cues, and it is generally understood that the amygdala is associated with fear conditioning

[45] B. R. Hergenhahn, *An Introduction to the History of Psychology* (Belmont, CA: Wadsworth Publishing, 2004).

[46] Olga Dal Monte, Vincent D. Costa, Pamela L. Noble, Elisabeth A. Murray, and Bruno B. Averbeck, "Amygdala Lesions in Rhesus Macaques Decrease Attention to Threat," *Nature Communications* 6, no. 1 (December 14, 2015). https://doi.org/10.1038/ncomms10161.

as well as extinction.[47] Numerous functional imaging (and related techniques) support a relationship between the amygdala and emotion processing, with a particular focus on fear. However, a meta-analyses of human neuroimaging studies found that the magnitude of the response of the amygdala to positive emotional stimuli is comparable to that observed with negative stimuli.[48]

The amygdala pathway receives information from the thalamus, which is an important relay center for incoming visual, auditory, and tactile information. It is generally understood that there are two pathways associated with this system. The first pathway was described above and serves as an alert system (often referred to as the "fast pathway"). A second pathway connects sensory areas of the cortex to the amygdala and is more deliberate in analysis of information (known as the "slow pathway"). This pathway provides an in-depth analysis of incoming sensory information and is sometimes considered a part of "top-down processing." This cortical-amygdala pathway provides rich analysis of incoming information that takes into account context and details. For instance, using my Appalachian Trail example, after the initial freeze response, the slow pathway provided additional information and detail that resulted in understanding that there was no threat.

The amygdala is also intertwined with a very important structure for encoding new memories, the hippocampus. It is, in general, thought that the amygdala serves to impart emotional significance of a stimulus, which in turn influences hippocampal encoding. It is generally accepted that the amygdala may enhance learning through the imparting of emotional significance. Anecdotally, humans tend to remember events with high emotional value as compared to events without the same intensity of emotion. Likewise, some studies indicated that the amygdala (along with other brain regions) plays a role in the resistance of emotional memories to extinction.[49]

[47] Joseph E. LeDoux, "Coming to Terms with Fear," *Proceedings of the National Academy of Sciences* 111, no. 8 (February 5, 2014): 2871–78. https://doi.org/10.1073/pnas.1400335111.

[48] Karine Sergerie, Caroline Chochol, and Jorge L. Armony, "The Role of the Amygdala in Emotional Processing: A Quantitative Meta-Analysis of Functional Neuroimaging Studies," *Neuroscience & Biobehavioral Reviews* 32, no. 4 (January 2008): 811–30. https://doi.org/10.1016/j.neubiorev.2007.12.002.

[49] Olena Bukalo, Courtney R. Pinard, Shana Silverstein, Christina Brehm, Nolan D. Hartley, Nigel Whittle, Giovanni Colacicco, et al, "Prefrontal Inputs to the Amygdala Instruct Fear Extinction Memory Formation," *Science Advances* 1, no. 6 (July 3, 2015). https://doi.org/10.1126/sciadv.1500251.

Our current understanding of the function of the amygdala also has broad application to a variety of mental health concerns including anxiety, phobias, and various trauma-related responses. In fact, many of these responses can be considered typical human behavior (though obviously contextually dependent). It is when such behaviors interfere with various facets of daily function that consideration of psychopathology is entertained. It is also easy to see how such phrases as the "amygdala has been hijacked" are rapidly adopted among those in the counseling profession as well as those who are being counseled. This attempt to simplify information sacrifices accuracy and is reminiscent of a phrase that was adopted many years ago ("I have a chemical imbalance that...."). Such phrases also suggest causal mechanisms that have *not* actually been tested empirically. In reality, the amygdala is not an isolated structure, as there are numerous cortical and subcortical connections that are dynamic and work in parallel. These structures, along with associated electrochemical properties, are constantly in flux and are important components of emotion processing.

Polyvagal Theory (PVT)

A second popular theory that is often applied to trauma is the Polyvagal Theory (PVT). First described by Stephen Porges,[50] it is an evolutionary theory that depicts the response and contribution of the autonomic nervous system as applied to behavior. Broadly speaking, the theory contains three components including the ventral vagal complex, the dorsal vagal complex, and the sympathetic-adrenal system.[51] It is theorized that "phylogenetically newer" higher neural circuits inhibit the lower circuits (which are putatively phylogenetically older), and that if the higher circuits cease to function then the lower circuits become more active. According to Porges, "The Polyvagal Theory links the evolution of the autonomic nervous system to affective experience, emotional expression, facial gestures, vocal communication and contingent social behavior. Thus, the theory provides a plausible explanation of several social, emotional and communication behaviors and

[50] Stephen W. Porges, "Orienting in a Defensive World: Mammalian Modifications of Our Evolutionary Heritage. A Polyvagal Theory," *Psychophysiology* 32, no. 4 (July 1995): 301–18. https://doi.org/10.1111/j.1469-8986.1995.tb01213.x.

[51] Porges, "The Polyvagal Perspective," *Biological Psychology* 74, no. 2 (February 2007): 116–43. https://doi.org/10.1016/j.biopsycho.2006.06.009.

disorders."[52] Appropriately, Porges also cautions that "Polyvagal Theory does not propose that the vagus is the ultimate cause of individual differences in social engagement behaviors or emotional regulation."[53]

According to the theory, the "lowest" of the anatomical circuits is the dorsal vagal complex, which is associated with immobilization or "freezing," "death feigning," or passive avoidance. The next circuit is sympathetic-adrenal system, associated with mobilization or active avoidance. The "most recent" component is the ventral vagus complex, which is associated with "social communication and calming, and inhibits arousal." Comprehensive review of the neuroanatomical circuits associated with PVT is beyond the scope of this paper, as these circuits are primarily subcortical and involve brainstem and cranial nerves (i.e., the Vagus nerve) that lead to target organs such as the heart. However, it is also thought that there are reciprocal connections from subcortical to cortical circuits, which in effect provides some inhibitory control or modulation of behavioral responses. As per Porges, it is the ventral vagal complex that forms the neuroanatomical foundation of the social engagement system (and presumably of most interest to those who provide counseling).[54] Within this system, there is a somatomotor component that is associated with regulation of the muscles of face and head and a visceromotor component the regulate the heart and bronchi. The model has been criticized within the literature (with rebuttal from Porges). In brief, some suggest that PVT may have heuristic value but that the concept of social engagement system through a "new ventral vagus" should be avoided.[55] Likewise, Paul Grossman suggested that the premises and assumptions of the five tenets of PVT are untenable, "based on past and present evidence."[56] Nevertheless, this model is applied to multiple facets of clinical intervention and there are numerous workshops

[52] Porges, "Emotion: An Evolutionary By-product of the Neural Regulation of the Autonomic Nervous Systema," *Annals of the New York Academy of Sciences* 807, no. 1 (January 1997): 62–77. https://doi.org/10.1111/j.1749-6632.1997.tb51913.x.

[53] Porges, "The Polyvagal Perspective," 132.

[54] Porges, "The Vagal Paradox: A Polyvagal Solution," *Comprehensive Psychoneuroendocrinology* 16 (November 2023): 100200. https://doi.org/10.1016/j.cpnec.2023.100200.

[55] W. Neuhuber and H.R. Berthound, "Functional anatomy of the vagus system: How does the polyvagal theory comply?", *Biological Psychology* 174 (2022): 108425. https://doi.org/10.1016/j.biopsycho.2022.108425.

[56] Paul Grossman, "Fundamental Challenges and Likely Refutations of the Five Basic Premises of the Polyvagal Theory," *Biological Psychology* 180 (2023): 108589. https://doi.org/10.1016/j.biopsycho.2023.108589.

and books on this topic. An important issue to note is that the model core is evolutionary in nature, which means the basic premises and assumptions are not truly testable or falsifiable.

Heart rate variability (HRV) is a key component of the Polyvagal Theory. In essence, HRV is reflective of variance in time between heartbeats. It is thought of as an indicator of activity in response to threats or social engagement. Overall, "more" variability is typically seen as better than "less" variability, as fluctuations in time between beats are thought of as adaptive. In contrast, less fluctuation is often associated with maladaptive regulation. When examining HRV, there are two main components. One component is a low-frequency component (LF, 0.04-0.15Hz) while the other is a high-frequency component (HF, 0.15-0.4 Hz). It is generally accepted among researchers that the high-frequency component is reflective of parasympathetic (vagal) nerve activity, which is typically of most interest when examining HRV. Heart rate variability is a useful research tool and also has clinical implications for heart health.

I have used this technique in my own research to examine individual differences in levels of hostility during emotional task performance.[57] Differences in HRV are observed as a function of hostility levels and task performance even among individuals that presumably do not have a psychiatric diagnosis (i.e., overall healthy young adults). In this sense, the individual differences noted in HRV are not diagnostic, but reflect physiological differences that are correlated with behavior. While in general, "more" HRV is thought of as adaptive and possibly reflective of better health, it is important to note that not all studies support this notion. For instance, Hill and Thayer have noted that despite elevated risk factors for stress and cardiovascular disease, African-Americans compared to European-Americans have increased HRV.[58] Likewise, as applied to neuroimaging, ethnic-related differences for the association between HRV and regional cerebral blood flow have been

[57] H.A. Demaree and D.E. Everhart, "Healthy high-hostiles: Reduced parasympathetic activity and decreased sympathovagal flexibility during negative emotional processing." *Personality and Individual Differences,* 36 (2004): 457-469. https://doi.org/10.1016/S0191-8869(03)00109-0.

[58] LaBarron K., Hill and Julian F. Thayer, "The Autonomic Nervous System and Hypertension: Ethnic Differences and Psychosocial Factors," *Current Cardiology Reports* 21, no. 3 (February 28, 2019). https://doi.org/10.1007/s11886-019-1100-5.

noted.[59] The implication here is that caution is warranted with application of theory to clinical practice, particularly if HRV is utilized as a marker of change or improvement.

Normalizing Stress and Response

Our world has changed dramatically with technology. There is now rapid access to a variety of information as popular media and social media provide communication platforms that convey a wide range of information. I can offer anecdotal information about the number of referrals for evaluation for ADHD and autism among teens and young adults, which have increased dramatically over the past 10 years. When I ask these patients why they want to be evaluated, they frequently make reference to seeing something on a social media platform that made them believe they meet the diagnostic criteria. I believe that similar principles apply to trauma. That is, we are inundated with information (with much of it being inaccurate) about what happens to the brains of individuals who have been traumatized. This belief is often perpetuated by pop psychology books and pseudoscience. In contrast, however, the majority of individuals who are exposed to stress (acute and long-term) continue to function at a healthy neuropsychological level.

One recent example of this is the work of a doctoral student of mine, Anya Savransky. In her master's thesis, she examined lifetime cumulative stress among young adults ages 18-25 and found no relationship between stress and neurocognitive function.[60] This study utilized a state-of-the-art assessment instrument for stress (The STRAIN) as well as standardized neuropsychological test batteries that were individually administered. Cumulative stress was not related to performance on standardized testing, suggesting no adverse neuropsychological effects at the time of evaluation. Of course, this study is limited in that it is reflective of a population of young adults in eastern North Carolina. One could easily argue that the results are not generalizable outside. However, all of the participants endured some stressors, with the most notably being COVID.

[59] Julian F.Thayer and Julian Koenig, "Resting Cerebral Blood Flow and Ethnic Differences in Heart Rate Variability: Links to Self-Reports of Affect and Affect Regulation," *NeuroImage* 202 (November 2019): 116154. https://doi.org/10.1016/j.neuroimage.2019.116154.

[60] A. Savransky, *Association between cumulative lifetime stress, cognitive function and sleep: The moderating effects of resilience.* Unpublished master's thesis, East Carolina University, 2023.

The fact that most individuals who endure stress remain healthy points toward the construct of *resilience.* One definition of resilience is "the process of adapting well in the face of adversity, trauma, tragedy, threats or even significant sources of stress."[61] However, as articulated by Anya Savransky, resilience is complex, and is associated with "individual genetic, biological, psychological, social and cultural factors."[62] It is thought that these factors influence how individuals respond to stress.[63] It is also intuitive (though perhaps not adequately tested at this time) that some exposure to stress early on may result in healthy adaptation to stress later on in life.

A similar facet is observed in a separate line of research noted as post traumatic growth (PTG). The theory holds that some who endure stress and adversity see positive growth afterword. This theory was developed by Richard Tedeschi and Lawrence Calhoun in the mid-1990s.[64] While there is an overlap with the concept of resilience, it is noted that PTG occurs after adverse effects of trauma where a person may find growth and change. While well beyond the scope of this paper, there is some research that links neuropsychological theory and anatomy to growth mindsets and intrinsic motivation.[65] Likewise, it is interesting to note that some holocaust survivors experience post traumatic growth though it is also acknowledged that the prevalence of a variety of psychological symptoms is higher in this population when compared to controls.[66]

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[61] American Psychological Association, "The road to resilience," Washington, DC: American Psychological Association, 2014, http://www.apa.org/helpcenter/road-resilience.aspx

[62] Savransky, "Association between cumulative lifetime stress."

[63] Steven M. Southwick, George A. Bonanno, Ann S. Masten, Catherine Panter-Brick, and Rachel Yehuda, "Resilience Definitions, Theory, and Challenges: Interdisciplinary Perspectives," *European Journal of Psychotraumatology* 5, no. 1 (October 1, 2014). https://doi.org/10.3402/ejpt.v5.25338.

[64] Richard G. Tedeschi, and Lawrence G. Calhoun, "The Posttraumatic Growth Inventory: Measuring the Positive Legacy of Trauma," *Journal of Traumatic Stress* 9, no. 3 (January 1996): 455–71. https://doi.org/10.1002/jts.2490090305.

[65] Betsy Ng, "The Neuroscience of Growth Mindset and Intrinsic Motivation," *Brain Sciences* 8, no. 2 (January 26, 2018): 20. https://doi.org/10.3390/brainsci8020020.

[66] Monika Fňašková, Pavel Říha, Marek Preiss, Petr Bob, Markéta Nečasová, Eva Koriťáková, and Ivan Rektor, "Lifelong Impact of Extreme Stress on the Human Brain: Holocaust Survivors Study," *Neurobiology of Stress* 14 (May 2021): 100318. https://doi.org/10.1016/j.ynstr.2021.100318.

While stress and related responses may reflect normal experiences of most humans, it is important to note that I am not making light of or minimizing the severe consequences that can occur among individuals who have been on the receiving end of trauma and associated sequelae. While numerous individual differences exist, effects of trauma and stress can be severe and hold long-term implications.

APPLICATION TO INTERVENTION

With such neuropsychological models, application to clinical populations is inevitable, appropriate and very important. One such well known work is the book The Body Keeps the Score by van der Kolk.[67] The content of this book attempts to integrate a mass amount of information including anecdotal, pseudoscience, and science into a coherent and understandable framework for understanding trauma (mostly PTSD) as well as provide recommendations for intervention that are mapped onto neuropsychological and neurophysiological theory and current understanding. The second part of this book describes relevant neuroanatomy and neurophysiology (including the work of LeDoux and Porges), and then subsequently utilizes this material to describe trauma-informed intervention in the last sections. The book is very engaging and provides an in-depth discussion of van der Kolk's personal experiences and his own clinical work and research. There is undoubtedly useful information within this book. However, as this book is not peer-reviewed, it is not surprising that there is also controversy and questions have surfaced regarding the legitimacy of some of the claims. In particular, there are questions about the lack of scientific evidence for some claims as well as errors with citations and misrepresentation of research. One recent book by Scheeringa provides an analysis of statements within *The Body That Keeps the Score* and suggests numerous errors in cited research that in some cases are irrelevant to the book material or inaccurate.[68] Detailed

[67] Bessel A Van der Kolk, *The Body Keeps the Score: Brain, Mind, and Body in the Transformation of Trauma* (New York: Viking, 2014).
[68] Michael Scheeringa, *Analysis of The Body Keeps the Score: The Science That Trauma Activists Don't Want You to Know* (Coppell, TX: Self-published, 2023).

analysis of all the claims is beyond the scope of this article, just as is analysis of Scheeringa's book. However, I would encourage readers to examine the source articles cited in van der Kolk's book and arrive at independent conclusions. If the claims of Scheeringa are indeed accurate, then the theory that is used to guide interventions (and potentially the actual interventions) becomes questionable. Proponents of The Polyvagal Theory as well as the content in van der Kolk's book point toward interventions that have existed in isolation of such theories. Two of these interventions are described below.

Neurofeedback

Neurofeedback (or neurotherapy) is derived from the encephalogram (EEG). The EEG has been used in clinical fashion for many years, and is useful in examination of seizure disorder, sleep disorders, and various encephalopathic conditions.[69] Recordings from scalp electrodes are amplified and then converted to digital technology where they are further processed. With the development of technology, the previous use of pens and ink to record on paper were abandoned, as computers can process the quantified data with efficiency and little error. With improved signal processing, the EEG can be separated into various frequency components as recorded in cycles per second. Thus, clinicians and researchers can examine the various frequencies known as delta, theta, alpha and beta. Researchers can examine the relative strength of each bandwidth (compared to other bandwidths, also known as power spectral analysis) as a function of time or task (such as performing mental math or stress inducing tasks). Individual differences can also be examined, and there are numerous potential applications. The various bandwidths are correlated with differing types of cognitive activity (such as attention and working memory) as a function of region (scalp electrode location) as well as emotional states. The premise of neurofeedback as a therapy is to "train" the brain through alteration of the power spectrum and resultantly improved mental or emotional state. It is similar in nature to biofeedback, where electrodes may be placed in specific muscles so that a patient can receive feedback as to when the muscle is relaxed. Patients purportedly learn to "train"

[69] "The Ten Twenty Electrode System: International Federation of Societies for Electroencephalography and Clinical Neurophysiology," *American Journal of EEG Technology* 10, no. 1 (March 1958): 371–75. https://doi.org/10.1080/00029238.1961.11080571.

their brain by viewing real-time recordings of brain waves, typically while playing a videogame that is controlled by brain waves.

Neurofeedback has been criticized due to lack of rigor in study. That is, there is historically a lack of double-blind procedures and sham controls.[70] However, studies have improved over time, and now, due to advancement in technology, changes in fMRI regional brain activity (and associated connections) as a function of intervention can be accordingly monitored. One such study examined changes in fMRI that was recorded pre and post treatment with neurofeedback. [71] This study utilized a PTSD sample and also included a sham control group as well as healthy controls. Changes in reported PTSD symptom severity were noted in the experimental group, which persisted with three month follow up. In addition, regional changes in connectivity (as measures by fMRI) were observed for the experimental group only (not the sham group or healthy controls). Due to the advancement of technology, it is now possible to perform neurofeedback while recording fMRI. One such study by Zotev and colleagues examined neurofeedback and fMRI changes among a group of PTSD combat veterans using a sham control procedure.[72] In brief, functional connectivity of the left amygdala, orbitofrontal cortex and dorsolateral prefrontal cortex was observed, with simultaneous reductions in PTSD symptom severity. Both of the papers described above also have significant limitations, which are appropriately described by the authors. For instance, Nicholson indicates that there were no differences in symptoms reported by PTSD patients in the experimental groups vs PTSD patients in the sham group post neurofeedback or at 3 months. This may point toward other mechanisms of change and as such caution is warranted.

[70] A. Nagappan, L. Kalokairinou, A. Wexler, "Ethical and Legal Considerations of Alternative Neurotherapies," *AJOB Neuroscience* 12, no. 4 (Oct-Dec 2021):257-269. doi: 10.1080/21507740.2021.1896601. Epub 2021 Mar 24. PMID: 33759705; PMCID: PMC8460707.

[71] A. A. Nicholson, T. Ros, M. Densmore, P. A. Frewen, R. W. J. Neufeld, J. Théberge, R. Jetly, R. A. Lanius, "A randomized, controlled trial of alpha-rhythm EEG neurofeedback in posttraumatic stress disorder: A preliminary investigation showing evidence of decreased PTSD symptoms and restored default mode and salience network connectivity using fMRI." Neuroimage: Clinical 28 (2020): 102490. doi: 10.1016/j.nicl.2020.102490. Epub 2020 Nov 5. PMID: 33395981; PMCID: PMC7708928.

[72] Vadim Zotev, Raquel Phillips, Masaya Misaki, Chung Ki Wong, Brent E. Wurfel, Frank Krueger, Matthew Feldner, and Jerzy Bodurka, "Real-Time FMRI Neurofeedback Training of the Amygdala Activity with Simultaneous EEG in Veterans with Combat-Related PTSD," *NeuroImage: Clinical* 19 (2018): 106–21. https://doi.org/10.1016/j.nicl.2018.04.010.

There are legitimate concerns regarding the use of neurofeedback as clinical intervention. These concerns have been discussed by Naggapan et al[73] and Wexler et al[74] through systematic study. In essence, it was observed that the majority of providers offering this service did not have doctoral degrees and questions of competency have surfaced. As intervention using this modality may cost $3,000 - $10,000, it is important to scrutinize the claims of efficacy among individual providers. Likewise, Naggapan et al provides a more in-depth review of some of the current limitations of this technique.

More recently, there are emerging systematic reviews that pertain to the efficacy of neurofeedback; some of which hold promise. For instance, one such review by Askovic et al suggests that neurofeedback is efficacious for managing symptoms of PTSD compared to controls.[75] Similar conclusions are drawn by Choi and colleagues who indicated that neurofeedback improves a range of symptoms associated with PTSD.[76] There are two additional points associated with these reviews. First, each of these contains a relatively small number of reviewed papers. For the interested reader, consider examination of the individual studies (source articles) that comprise these reviews, as they differ in methodology in various ways. Second, while neurofeedback may hold promise, at present there is little research that examines (within the same study) efficacy of neurofeedback versus well established forms of intervention such as exposure therapy or cognitive-behavioral therapy. Future studies that consider these issues will be important and informative.

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[73] A. Nagappan, L. Kalokairinou, A. Wexler, (2021) "Ethical and Legal Considerations of Alternative Neurotherapies," *AJOB Neuroscience* 12, no. 4 (Oct-Dec 2021):257-269. doi: 10.1080/21507740.2021.1896601. Epub 2021 Mar 24. PMID: 33759705; PMCID: PMC8460707.

[74] A. Wexler, A. Nagappan, D. Kopyto, and R. Choi, "Neuroenhancement for sale: Assessing the website claims of neurofeedback providers in the USA," *Journal of Cognitive Enhancement* 4, no. 4 (2020): 379–88. doi: 10.1007/s41465-020-00170-8.

[75] Mirjana Askovic, Nerissa Soh, James Elhindi, and Anthony Harris, "Neurofeedback for Post-Traumatic Stress Disorder: Systematic Review and Meta-Analysis of Clinical and Neurophysiological Outcomes," *European Journal of Psychotraumatology* 14, no, 2 (2023). https://doi.org/10.1080/20008066.2023.2257435.

[76] Yun-Jung Choi, Eun-Joo Choi, and Eunjung Ko, "Neurofeedback Effect on Symptoms of Posttraumatic Stress Disorder: A Systematic Review and Meta-Analysis," *Applied Psychophysiology and Biofeedback* 48, no. 3 (2023): 259–74. https://doi.org/10.1007/s10484-023-09593-3.

Eye Movement Desensitization and Reprocessing (EMDR)

Eye Movement Desensitization and Reprocessing (EMDR), initially developed by Francine Shapiro, has been used to treat patients with PTSD.[77] While the intervention has multiple stages, an important component entails focus on aspects of traumatic memory or events while tracking the finger of the therapist as it moves back and forth. In simple fashion, it is thought that the eye movements allow for integration and processing of the traumatic memories.

Comprehensive review of the proposed neuropsychological systems associated with EMDR is beyond the scope of this manuscript. However, Rousseau et al examined neuroanatomical correlates via fMRI recorded during a negative face processing task in patients with PTSD compared to healthy controls.[78] Patients were imaged prior and after treatment with EMDR and it was found that during the task, there were significant decreases in subcortical structures such as the amygdala, thalamus, and caudate) as well as cortical structures including the ventromedial and dorsolateral prefrontal cortex. In addition, increased right thalamic activity was positively associated with symptom reduction. The authors discuss appropriate limitations for this study in that the retest effect of the task (before and after therapy) was counterbalanced by the retest effect in healthy controls. These authors also indicate appropriate caution and suggest that the utilized statistical thresholds for functional brain activity do "not rule out that the structures identified are not activated by chance." They suggest additional research is warranted in order to replicate and confirm results.

It is important to note that the observed changes in functional activity map onto some of the neuroanatomical structures described by Le Doux (i.e., amygdala and thalamus as well as portions of the cortex). Thus, this study provides some support (as with numerous others) that the amygdala and thalamus are related to emotion processing and the functional activity of these regions is sensitive to interventions and behavioral changes.

[77] Francine Shapiro, *Eye Movement Desensitization and Reprocessing (EMDR): Basic Principles, Protocols, and Procedures,* 2nd ed. (New York: Guilford Press, 2011).

[78] Pierre-François Rousseau, Myriam El Khoury-Malhame, Emmanuelle Reynaud, Sarah Boukezzi, Aïda Cancel, Xavier Zendjidjian, Valérie Guyon, et al., "Fear Extinction Learning Improvement in PTSD after EMDR Therapy: An FMRI Study," *European Journal of Psychotraumatology* 10, no. 1 (2019): 1568132. https://doi.org/10.1080/20008198.2019.1568132

For years, there has been controversy with EMDR, as the mechanism(s) of the eye movements as they pertain to trauma are not understood. This intervention also contains additional pre-existing forms of intervention such as "exposure therapy." In addition, some have purported that the efficacy of treatment using EMDR is no better than another efficacious form of treatment, Cognitive Behavior Therapy, as both components contain exposure. At present, the American Psychological Association (APA) considers this intervention as "conditionally recommended."[79] In contrast, Cognitive Behavior Therapy is "strongly recommended."[80] The difference is in part associated with relatively less evidence supportive of EMDR, as well as the controversy associated with mechanism of action in EMDR. However, the American Psychiatric Association (APA) recommends both CBT and EMDR as efficacious interventions.[81]

Early meta-analyses of EMDR found no difference in efficacy when compared to other exposure-based therapies.[82] Seidler and Wagner found similar results.[83] Interestingly, a more recent meta-analysis that also examined PTSD and additional mental health problems beyond found that "EMDR may be effective in the treatment of PTSD in the short term, but the quality of studies is too low to draw definite conclusions. There is not enough evidence to advise it for the use in other mental health problems."[84] Within this analysis, the authors comment that the number of studies available was small and

[79] American Psychological Association, "Eye Movement Desensitization and Reprocessing (EMDR) Therapy," July 31, 2017. https://www.apa.org/ptsd-guideline/treatments/eye-movement-reprocessing.

[80]American Psychological Association, "Cognitive Behavioral Therapy (CBT) for Treatment of PTSD," 2017, https://www.apa.org/ptsd-guideline/treatments/cognitive-behavioral-therapy.

[81] American Psychiatric Association, "Practice Guideline for the Treatment of Patients with Acute Stress Disorder and Posttraumatic Stress Disorder," 2004. https://www.cstsonline.org/assets/media/documents/workplacepreparedness/APAPracticeGuidelines.pdf.

[82] Paul R Davidson and Kevin C. H. Parker, "Eye Movement Desensitization and Reprocessing (EMDR): A Meta-Analysis," *Journal of Consulting and Clinical Psychology* 69, no. 2 (2001): 305–16. https://doi.org/10.1037/0022-006x.69.2.305.

[83] Guenter H. Seidler and Frank E. Wagner, "Comparing the Efficacy of EMDR and Trauma-Focused Cognitive-Behavioral Therapy in the Treatment of PTSD: A Meta-Analytic Study," *Psychological Medicine* 36, no. 11 (2006): 1515. https://doi.org/10.1017/s0033291706007963.

[84] Pim Cuijpers, Suzanne C. van Veen, Marit Sijbrandij, Whitney Yoder, and Ioana A. Cristea, "Eye Movement Desensitization and Reprocessing for Mental Health Problems: A Systematic Review and Meta-Analysis," *Cognitive Behaviour Therapy* 49, no. 3 (2020): 1–16. https://doi.org/10.1080/16506073.2019.170380

the risk of bias was high. Within this context, bias refers to sources of bias in randomized controlled trials. Specifically, bias in clinical trials may occur in aspects of trial design, conduct, and reporting. High risk bias diminishes confidence in finding and application of those findings accordingly.

Considerations For Evaluation of Research and Applied Interventions

There are a variety of important issues to consider when reading relevant research associated with trauma. While not exhaustive, it is hopeful that this list is useful in decision making with regard to explanatory models and interventions when working with individuals who report trauma.

1. Book authors (of science) are often faced with the difficult task of synthesizing and integrating vast amounts of research that is supportive (or non-supportive) of the theories that they desire to promote. As a result, many of the relevant details are not covered in depth or are excluded. The overall effect is sacrificing accuracy for simplicity.

2. Books that promote a scientific theory as well as interventions are often not peer-reviewed in the manner that research articles are. During the submission of research articles, manuscripts are often critically evaluated by at least three experts in the field and the editor ultimately makes a decision to accept, accept with revisions, revise and resubmit or reject. For books, the opportunity for professional criticism and evaluation of the potential weaknesses happens post-publication. However, many readers assume that the statements and assertions made within such books have been thoroughly investigated and have support among other researchers. In essence, a book that hasn't been peer reviewed is one of the lowest on the list of places to look for credible and thoroughly tested research.

3. Books are profit driven (while most of the time research journal articles are not), which means that there are attempts to highlight and market to target audiences. While not inherently bad, due caution is recommended.

4. In order to illustrate points and make the work interesting, authors may use anecdotal information. It is important to remember that this is not

science, but may indeed provide interesting information that leads to theoretical development.

5. Some books also include pseudoscience in an attempt to influence readers. Pseudoscience comes in many forms but may include faulty premises, flawed research, spurious findings and sensationalized claims about research findings. Such work is not falsifiable and alternate explanations and hypotheses are almost never provided.

6. For trauma research, and in particular related to neurophysiology, almost all of the studies are cross-sectional. As a result, causality cannot be determined, though it is often inferred. In reality, it is very difficult to do longitudinal studies in neuroimaging and trauma, as researchers would have to follow large numbers of individuals and frequently examine for the presence of trauma versus no trauma.

7. Functional neuroimaging is an exciting and continuously developing area of research, particularly as it involves trauma research. However, as indicated, almost all of the fMRI studies are cross-sectional, which again leaves causality undetermined. Another relevant and extremely important issue is difficulty with replication. As indicated by Elliott et al, a meta-analysis of fMRI studies suggests poor intra-class correlations among replication studies.[85] The authors conclude: "Collectively, these findings demonstrate that common task-fMRI measures are not currently suitable for brain biomarker discovery or for individual-differences research."[86] The implications for the current state of this research are extraordinary.

8. Studies of neurophysiology, neuroimaging, and related fields frequently examine individual differences within discrete points in time (or brief intervals) within a laboratory setting. It is important to remember that human interactions are dynamic and not discrete. Related, unlike such clinical measurements as heart rate or blood pressure, to date (to the

[85] Maxwell L. Elliott, Annchen R. Knodt, David Ireland, Meriwether L. Morris, Richie Poulton, Sandhya Ramrakha, Maria L. Sison, Terrie E. Moffitt, Avshalom Caspi, and Ahmad R. Hariri, "What Is the Test-Retest Reliability of Common Task-Functional MRI Measures? New Empirical Evidence and a Meta-Analysis," *Psychological Science* 31, no. 7 (2020): 792–806. https://doi.org/10.1177/0956797620916786.
[86] Ibid.

knowledge of this author) there is no accepted index or range for HRV or fMRI activity that is diagnostic. To this extent, one cannot go to the local pharmacy and take an HRV reading (and resultantly follow up with a physician due to aberrant HRV).

9. When evaluating clinical research and in particular efficacy (and recommendations) for intervention, many societies use a tiered system evidence-based approach. There are multiple frameworks for this, but the stronger evidence for utilization tends to come from randomized controlled trials, systematic reviews, and meta-analysis. For an initial review of how this research is conceptualized, consider Burns et al as a starting point.[87] Within the behavioral sciences, similar strategies are utilized. For instance, the American Academy of Sleep Medicine (AASM) utilizes a similar grading approach when recommending evidence-based interventions (such as for treatment of insomnia). So if there is consideration of adopting a particular intervention, consult with major professionally related societies and look for the rigor that is used when recommending an approach.

10. Many researchers understand the complexity of human dynamics and most do not attempt to reduce to isolated neuroanatomical structures. In 2010, Research Domain Criteria (RDoC) was introduced as a way to examine these complicated systems.[88] Though RDoC focuses primarily on biological mechanisms for explaining behavior (and in this author's opinion produces additional shortcomings through not recognizing environmental contributions), it moves away from utilization of a certain "number" or "types" of symptoms required to meet diagnostic criteria.

11. I strongly encourage readers to consult the original source articles when evaluating the efficacy of research.

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[87] Patricia Burns, Kevin Chung, and Rod Rohrich, "The Levels of Evidence and Their Role in Evidence-Based Medicine," *Plastic and Reconstructive Surgery* 128, no. 1 (2011): 305–10. https://doi.org/10.1097/PRS.0b013e318219c171.

[88] Thomas Insel, Bruce Cuthbert, Marjorie Garvey, Robert Heinssen, Daniel S. Pine, Kevin Quinn, Charles Sanislow, and Philip Wang, "Research Domain Criteria (RDoC): Toward a New Classification Framework for Research on Mental Disorders," American Journal of Psychiatry 167, no. 7 (2010): 748–51. https://doi.org/10.1176/appi.ajp.2010.09091379.

12. Related to point #11, caution is urged when using search engines for materials. Messeri and Crockett have commented on the emergence of artificial intelligence (AI) in science.[89] Your search may produce AI results that are inherently non-factual. For example, I recently had a colleague (RC) tell me that he did a search on his scholarly activities and an article was produced with his name inserted as the author. The article was fabricated through AI.

CONCLUSIONS AND FINAL RECOMMENDATIONS

The controversy and research limitations previously described may present as disheartening to some of the readers of this article. However, this is not the purpose of this essay. Rather, the purpose is to encourage biblical counselors to critically evaluate available research and make informed decisions regarding utilization (or recommendation thereof) of interventions. Biblical counselors inherently have to make a choice on whether to utilize popular theory (in some cases, theories that are based on evolution, for instance) and whether such theory is consistent with their biblical worldview (as well as whether or not they want to expose their clients to such theory). Likewise, biblical counselors must evaluate whether the proposed intervention flows from science and efficacy and is consistent with the biblical view.

In cases where a biblical counselor may not have the background to evaluate such research and outcome, in absence of further training and study, my advice is to exercise extreme caution and avoid. However, I would have enthusiastic hope that most biblical counselors are interested in further training in neuroscience and would encourage all to seek knowledge that applies to understanding research studies about intervention. Within my own field and among my clinical psychology colleagues in my department, it is interesting to note that most (yes, anecdotal) are deliberately cautious about attaching themselves to interventions that do not have strong empirical support. This may reflect philosophical differences between professions and/or how science is utilized.

[89] Lisa Messeri and M. J. Crockett, "Artificial Intelligence and Illusions of Understanding in Scientific Research," *Nature* 627 (2024): 49–58. https://doi.org/10.1038/s41586-024-07146-0.

Last, I would encourage biblical counselors interested in research to pursue randomized controlled trials RCTs related to biblical counseling. I suspect that further examination via this method would produce some interesting and fruitful results for the field. One such recent example exists with Knabb and colleagues who evaluated the effects of Christian meditation.[90] As indicated in the beginning of this manuscript, I am not an expert in biblical counseling and not necessarily qualified to review related research and in particular the utility of the aforementioned study. However, I am hopeful for the future of biblical counseling and look forward to reading more studies in this area.

[90] Joshua J. Knabb, Veola E. Vazquez, Fernando L. Garzon, Kristy M. Ford, Kenneth T. Wang, Kevin W. Conner, Steve E. Warren, and Donna M. Weston, "Christian Meditation for Repetitive Negative Thinking: A Multisite Randomized Trial Examining the Effects of a 4-Week Preventative Program," Spirituality in Clinical Practice 7, no. 1 (2020): 34–50. https://doi.org/10.1037/scp0000206.