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The importance of Neuro-Cognitive Processing to the Understanding and Treatment of Child PTSD

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Abstract

Basic research and current clinical practice have revealed the difficulty in separating/connecting cognition and emotion and their respective localizations in the brain. Regarding Post-Traumatic Stress Disorder (PTSD), emotions (usually fear) cause a cascade of symptoms, including those impacting several cognitive processes. And it is often considered that relieving the emotional upset associated with PTSD will also improve related cognitive functioning. While it is often assumed that the relationship of emotion, cognition and PTSD is unidirectional, this may not necessarily be the case. The present article aims to describe the complex relationship between emotion and cognitive processes in those with PTSD and suggests an important role for executive functioning as a modulator of the emotion/cognition relationship, as well as the latter's importance as a contributor to the successful treatment of PTSD. The paper concludes by stressing the importance of assessing cognitive processes in standard treatment protocols evaluating patients with PTSD and highlights the potential benefits of training executive functions as part of PTSD therapy.

Keywords: PTSD, Cognitive processes, Emotion, Executive function, Neuropsychology.

Introduction

Proposed in the mid 1880's, the James-Lange theory of emotion suggests that both physiological responses and cognitive processes are fundamental to explanatory models of clinical disorders in which emotional alteration is considered the root cause. This view seems particularly on-point when describing Post-Traumatic Stress Disorder (PTSD). Most explanatory models of PTSD are built upon the notion that fear via exposure to a traumatic experience is the driving force behind the resultant cascade of negative PTSD symptomatology. Generally, these models claim that exposure to traumatic experiences creates a strong emotional reaction that people are unable to deal with, resulting in feelings of fear or dysphoric mood states (Lissek & van Meurs, 2015). From this perspective, the collateral cognitions associated with a given traumatic event are a secondary consequence of a generalized and essentially automatic emotional response. Based on this idea, most clinical therapies for treating PTSD focus on reducing the intensity of the given emotional reaction, either by sensitizing the physiological response or modifying the emotions associated with the traumatic event (e.g., Cahill, & Foa, 2007).

However, growing evidence suggests that numerous models of PTSD are missing an additional and very important component—cognitive mediation. Specifically, emotions are not solely passive reactions in which humans automatically respond to a given stimulus event, but evolve into active cognitive re-constructions associated with the given emotional experience. The arguments in support of this idea come from the so-called Theory of Socio-Cultural Constructed emotions (see Barrett, 2017). Among other aspects of this theory, it challenges the widely accepted notion of the "universality" of all emotional experiences and may question the corresponding neurocognitive processes (e.g., localization of specific brain circuits) underlying the experience of a given emotion. Regarding PTSD, the theory dismisses the idea that a given traumatic event is experienced similarly for all social-cultural groups and further emphasizes that one's social-cultural environment uniquely shapes the perceptions, emotions, and cognitions engendered by traumatic experiences.

Some recent evidence highlights the importance of underlying cognitive processes (e.g., attention, memory, and executive functions) to responses to a given traumatic event. Even though many models of PTSD include a cognitive component in their explanations, they usually do so only as an afterthought rather than positing cognitive processes as a central component of the disorder. Furthermore, they often conclude that therapy which relieves the emotional aspect of a response to a traumatic event will concurrently produce a corresponding improvement in cognitive functioning.

A central thesis of this paper, however, is that rather than an incidental consequence of exposure to traumatic experiences, cognitive processes play an important underlying causal role in the development of emotional responses to them, like those leading to PTSD. Notably, this claim has received some empirical support with several recent PTSD studies revealing deficits in attention, memory, IQ, and especially aspects of executive functioning (e.g., planning and cognitive flexibility) as well as working memory (Young-Southward et al., 2020). Additionally, studies also suggest deficits in inhibitory control (a process mainly mediated by frontal lobe development) that contribute to the creation and subsequent unwanted maintenance of debilitating emotional responses like those found in PTSD. Notably, the finding of cognitive

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deficits in emotional responses that have been shown primarily in adults, are often found in studies of children with PTSD as well, particularly with regard to inhibitory control and the related underdevelopment of the frontal lobes (the latter mediating aspects of executive functioning (e.g., Doebel, 2020).

The latest version of the American Psychiatric Association (APA, 2022) identifies the essential feature of PTSD disorder as the development of negative behavioral symptoms following exposure to one or more traumatic events. The symptoms of PTSD are organized into four categories: 1) intrusion, 2) avoidance, 3) negative alteration in cognitions and mood, and 4) altered arousal and reactivity. The DSM 5-TR provides an extensive description of the developmental differences in PTSD symptomatology in children aged six and younger (APA, 2022). Note that exposure to traumatic events is not uncommon in childhood and according to McLaughlin et al. (2013) and Danese, (2020) , more than 60% of children have been exposed to traumatic events by 16 years of age, and more than 30% of them have experienced multiple traumatic events. Exposure to traumatic events is a known predictor of PTSD and other common childhood emotional (e.g., depression and anxiety) and behavioral problems (e.g., Oppositional Defiant Disorder), (Copeland et al., 2018). Based on a prospective cohort study of 1420 participants, McLaughlin et al. (2013) conclude that childhood trauma exposure is correlated with higher rates of adult psychiatric disorders and dysfunctional behavioral outcomes. Curiously, in some instances, trauma has unexpectedly produced positive outcomes including enhanced resilience and posttraumatic growth (Oshri et al., 2017). Interestingly, Kent et al. (2014) have identified executive functioning as a key factor associated with increased psychological resilience. Beyond the usual emotion-based explanations of the symptoms associated with PTSD, the above findings lead to consideration of more cognitively based factors as important contributors to the development of PTSD.

Given the significant negative impact of early traumatic experiences on mental health and the growing evidence concerning the importance of cognitive processes in the development of disabling psychological conditions like PTSD, the focus of the present article is to describe the relationship between emotion and cognition, highlighting the role of executive function as a potential contributor to PTSD, particularly in children. In the first part of the paper, we describe the complex interaction between emotion and cognitive process, while in the second part we discuss child trauma from a neurodevelopmental perspective, highlighting maturation of frontal lobes and the development of executive functions. Finally, we describe the implications such theorizing has for the neuropsychological assessment and treatment of child PTSD, again emphasizing the importance of executive functioning.

The relationship between emotion and cognition

According to Dolcos et al. (2011), "emotions may affect various aspects of cognition and behavior by enhancing or hindering them and by exerting both transient and long-term influences" (p. 669). These authors suggest that processing emotion is susceptible to cognitive influences. Accordingly, a potential bi-directional relationship makes it possible to potentially explain the wide variety of (and sometimes contradictory) symptoms/behaviors that individuals exhibit after exposure to a traumatic experience. It is important to note that humans are not passive witnesses to such events but are active interpreters of the

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meaning of a given traumatic experience. This is true not only for PTSD but a variety of other mental disorders. In the end, mental health emerges from an intricate network of factors influencing each other, which may cloud the issue of what is cause and what is consequence. Moreover, emotional and cognitive processes typically go hand in hand, being both explicit and implicit. In PTSD exposure to traumatic events may cause implicit or explicit emotional dysregulation and, it also influences the cognitive processes activated during such exposure.

Traditionally, the study of the neurobiology of trauma is based on the idea of parceling the brain into either higher-order cognitive or subcortical emotional regions/structures. This view suggests that cognition is a controlled process mainly mediated by cortical engagement, whereas emotion is an automatic process primarily mediated by subcortical structures. However, as Pessoa (2008) has pointed out, this view is problematic since affective/emotional brain areas are also engaged during higher order cognition. Indeed, current evidence suggests that cognition and emotion are well integrated in the brain. For example, a study by LeDoux et al.(1985) and in the meta-analysis conducted by Lindquist et al. (2012) both have found a crucial role for the amygdala in eliciting fear responses, often as a by-product of classical conditioning. However, Pessoa (2008), and others point out that the amygdala is also involved in a wide range of higher order cognitive functions, among them cognitive mediation of emotional states like sadness (Killgore & Yurgelun-Todd, 2004), disgust, and happiness (Kipps et al., 2007). Note that the amygdala is also very active in cognitive processes like visual attention (Domínguez-Borràs et al., 2020), social decision-making (Gangopadhyay et al., 2021), and memory (McGaugh et al., 2019).

The role of the amygdala in both emotional and cognitive processing can be theorized to reflect the fact that it is part of an intricate neural system connecting itself with at least eight different cortical areas and several other subcortical structures (Young et al., 1994). This networking provides for both automatic and controlled aspects of emotional and cognitive processing. Perhaps more importantly, this integrated network like approach challenges the idea of separable brain structures/regions devoted solely to emotion versus cognitive processing. Furthermore, other subcortical limbic ("emotional") structures like the insula are known to mediate aspects of language processing (Gasquoine, 2014), and the nucleus accumbens is believed to be involved in the judgement and subsequent suppression of inappropriate actions (Floresco, 2015). Regarding cortical areas, the prevalent view suggests that they mediate mostly higher-level cognitive processes (e.g., language, memory, attention, and executive functions), but the fact remains that many cortical areas depend on their connection with subcortical regions/structures for complete functioning. This is thought to reflect the fact that subcortical (e.g., limbic) areas provide an affective tone to cognitive functions and offer helpful interoceptive information that enhances the completeness of a given cognitive representation. It is well known that cortical areas play a crucial role in the experience of emotion. For example, the prefrontal cortex (PFC) is essential for manipulating and maintaining information (D'Esposito et al., 2000; Pochon et al., 2001) and is also believed to mediate cognitive control functions (Koechlin et al., 2003), particularly by providing the emotional/affective component of incoming information (Ardila, 2013; Ardila, 2008).

Given current advances in neuroscience it is now possible to segment cortical areas like the PFC, into regions based on

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functional specialization, their cytoarchitecture, and their connectivity. Several authors have identified specific cortical (rather than subcortical) areas involved in emotion processing. For instance, the anterior cingulate cortex is associated with the attention driving the cognitive processing of emotion laden stimuli (Bush et al., 2000). And the orbitofrontal cortex plays a fundamental role in integrating emotional components of information used during decision-making (Bechara et al., 2000). Even the dorsolateral prefrontal cortex, generally associated only with the highest-level cognitive processes (e.g. metacognition, reasoning) is known to make a significant contribution to emotion processing. For example, Nejati et al. (2021) have reported activation of this brain region when regulating the emotional valence of an incoming stimuli.

Based on the evidence briefly presented above, it may be argued from a neurobiological point of view that the distinction between emotion and cognition is mainly semantic. The evidence briefly discussed so far suggests that several cortical areas and subcortical brain structures are interconnected to form a functional unit (s). In this context, rather than thinking of emotion as its own unique state (Nussbaum, 2001), it may be more accurate to consider emotion as a form of bodily arousal, which is cognitively built upon by combining the emotional/physiological input with subsequent cognitive processes designed to create a given emotional experience and one's response to it (James, 1884; Damasio, 1994).

Child trauma and executive functioning: A neurodevelopmental view

As mentioned in the first part of the paper, executive functioning is a cognitive process that seems intimately connected to child PTSD (Lund et al., 2020; Malarbi et al., 2017; Barrera-Valencia et al., 2017). Among the three main components of executive functioning (i.e., working memory, inhibitory control, and cognitive flexibility; see Diamond, 2013), inhibition is well known to be associated with traumatic experiences in childhood (Barrera et al., 2013; Van der Bij et al., 2020). Although it is not yet possible to identify a precise etiopathogenic mechanism underlying the relationship between trauma and executive functioning, the importance of frontal lobe development is at the forefront of ongoing research. In such investigations, evaluating controlled (i.e., mediated by cortical brain areas) versus automatic processes (i.e., mediated by subcortical brain structures) is often the focus. For example, when children learn a new motor skill (e.g., learning to walk), prefrontal areas are very active, but as the skill level of the child increases, these frontal areas become less engaged. The latter is due in part to the fact that repetition leads to eventual automatization of the behavior. This learning process is facilitated by subcortical structures (mainly the basal nuclei) that eventually become more active and engaged than cortical areas.

Contrastingly, emotion is initially a predominantly automatic process that may become more cognitively mediated as time goes on. Note that emotions in newborns are supported primarily by subcortical structures. But with age, during the socialization process, children learn to handle their emotional states via cognitive mediation, such that emotional states become more and more under cortical control.

Of importance to our understanding of PTSD is the growing evidence suggesting that early traumatic experiences may interrupt shifts from automatic to controlled processing of emotional events. For example, Calderon-Delgado et al. (2020) showed cortical-subcortical differences

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between children with PTSD and neurotypical controls during performance of an emotional word processing task, one requiring subjects to determine if the presented word reflected a positive or negative emotional valence. Specifically, they compared behavioral responses and related brain activation patterns when identifying positive words (e.g., joy, play) versus negative words (e.g., murder, rape). At the behavioral level they found fewer correct identifications (and longer reaction times) overall for children with PTSD, a pattern that was accentuated when attempting to classify words depicting negative emotional valence. Notably, PTSD children also showed less activation of cortical areas and greater activation of subcortical structures for such word processing, as compared to the neurotypical group; the latter tending to show greater activation of cortical areas and less activation of subcortical structures during task performance (Figure 1).

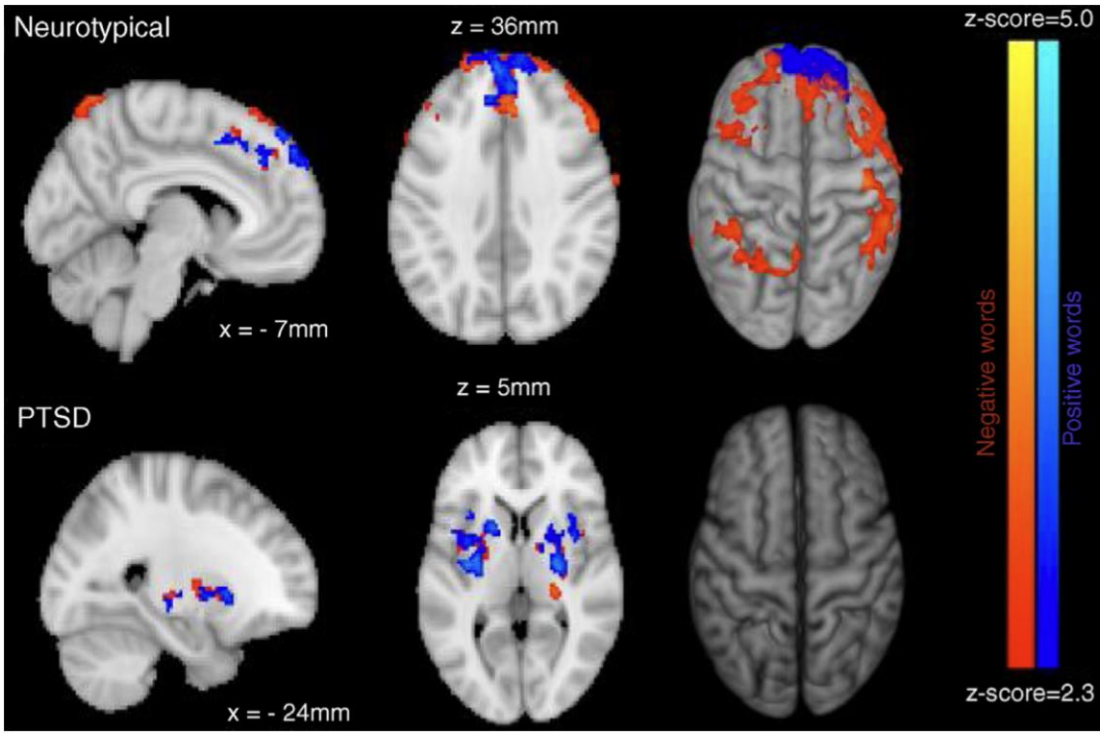

Figure 1. Activation patterns for neurotypical (on the top) and PTSD children (on the bottom) while participants identify words as having either positive or negative emotional valence. The neurotypical exhibited more cortical/frontal activation in both conditions, whereas the PTSD participants displayed activation primarily in subcortical structures (Calderón-Delgado et al. 2020).

Calderon-Delgado et al. (2020), have posited that such a processing difference might be due to the implicit vs. explicit aspect of such processing, although it is also possible to explain the pattern of results in terms of automatic versus controlled processes. Note that automatic processes tend to be carried out in an implicit-subcortical manner, while controlled processes tend to be conducted in a more explicit-cortical manner. In either case, these results may reflect an interruption of the emotional processing of words by inhibiting the shift from automatic subcortical processing to a more cortically mediated cognitive control process. Note that Marusak et al. (2015) have reported similar results. In their study

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they compared fMRI data from 14 children with trauma and 16 neurotypical participants, while determining if a human facial expression matched (or did not match) an emotion laden word superimposed on the face. Their results showed greater interference in such processing in the trauma participants, and reported greater activation of subcortical versus cortical regions, suggesting a deficit in conflict regulation via the aforementioned cognitive switching.

In the adult population, results to those found in child PTSD have been reported. For instance, in their meta-analysis Etkin and Wager (2007), compared brain imaging studies that contrasted a negative emotional experience condition with a neutral or positive emotional experience condition and did so across several samples: 15 studies with PTSD subjects, 8 with social anxiety disorder, and 5 with a specific phobia. They found greater activation of the amygdala and the insula in all three groups. However, only patients with PTSD exhibited hypoactivation of the dorsal and rostral anterior cingulate cortices as well as the ventromedial prefrontal cortex. In contrast to the behavioral results of studies involving children with PTSD, it might be mentioned that PTSD adults demonstrate a broader alteration in executive function (Barrera-Valencia, 2016). For example, Ben-Zion et al. (2018) reported a specific deficit in cognitive flexibility that was predictive of symptom severity in a sample of adults with PTSD. Nejati et al. (2018) have also reported a modification of working memory for processing emotional versus non-emotional information in PTSD adults. Generally speaking, these results hint that a different mechanism may underly traumatic responses in adult PTSD as compared to child PTSD.

Conclusion

The present article aimed to describe the relationship between emotion and cognition, characterizing the connection between the two as primarily automatic versus controlled processing, as well as highlighting the important role of executive functions as a modulator of the relationship, particularly as it pertains to child PTSD. Whereas the popular view of emotion (particularly fear) is at the core (and cause) of traumatic responses, this article highlights the complex interaction between emotion and cognition to explain the mechanisms behind PTSD. From a neurodevelopmental point of view, it is likely that traumatic experience is not solely an automatic emotional response, but has a significant cognitive component, with the latter playing a crucial role in controlling (or failing to control) emotional states. Figure 2 outlines how the interruption of such control processes may result in a debilitating condition like PTSD (Figure 2).

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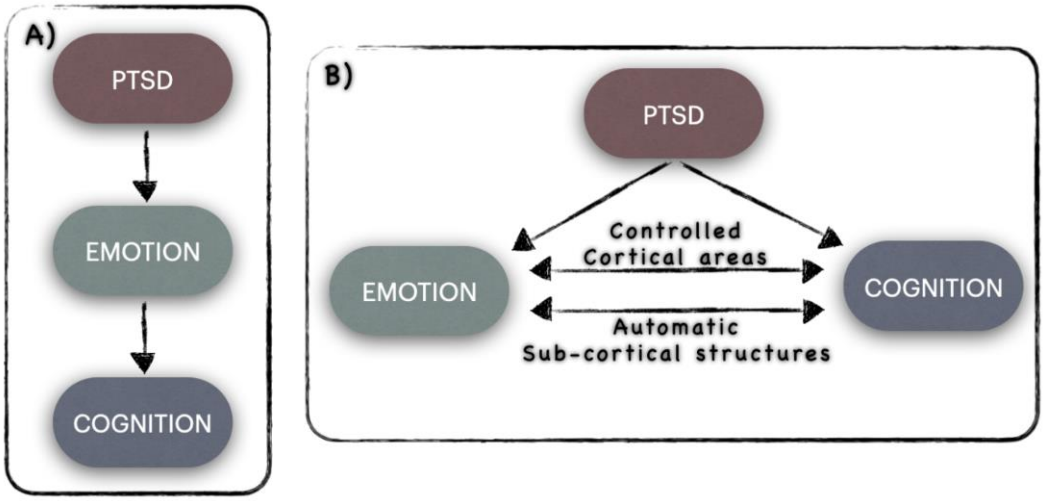

Figure 2: Panel A describes the relationship between PTSD, emotion, and cognition. This view assigns a somewhat passive role to cognition, rather than elevating it to a component that is central to the traumatic reaction. In contrast, panel B describes the dynamic relationship between emotion and cognition as it pertains to PTSD. Specifically, the exposure to traumatic experiences interrupts the shift of emotion from an automatic to a controlled cognitive process, with those individuals failing to gain cognitive control of their emotions being more likely to develop PTSD. From a neurobiological conceptualization, PTSD is thought to be the result of the failure of executive functions to mediate the switch from automatic regulation of emotion to cognitive controlled mediation. Note that these executive functions are closely linked to the development of the frontal lobes and any alteration of such development will have a significant impact on executive functioning.

It is important to note that if emotion and cognition are in a complex bi-directional relationship of influence as suggested above, it has important clinical implications for the treatment of PTSD. Specifically, PTSD treatment focused on improving cognitive skills should have a significant impact on recovery from traumatic experiences (Jacob et al., 2019). For example, Falconer et al. (2013) provide evidence that an eight-week cognitive behavioral therapy intervention designed to increase inhibitory control was predictive of enhanced PTSD treatment outcomes Furthermore, a model proposed by Aupperle et al. (2012) highlights the role of inhibitory control in the development of symptoms associated with PTSD, emphasizing the difficulty some PTSD patients have in disengaging from the emotional reactions induced when re-experiencing a “triggering” stimulus or event.

Training in executive functioning in children has become increasingly popular due to its potential benefits, particularly as demonstrated in increasing academic achievement and promoting social success (Zelazo & Carlson, 2020). Based on the current evidence, it seems reasonable to develop clinical interventions that improve their cognitive skills and minimize (or prevent) the effects of traumatic experiences in early childhood, this accomplished by incorporating novel techniques like scaffolding and self-reflection (Zelazo, 2020). The latter skills may help mitigate the disruptive bottom-up influences that are often attributed to the emergence of PTSD. As Aupperle et al. (2012) have stated, "it is hoped that by incorporating knowledge from cognitive and neuroscientific research, we can develop novel treatments that will allow us to treat those suffering from PTSD more successfully" (p.691). Given the tremendous impact early traumatic experiences have on the mental health of children, this may be especially true for the treatment of child PTSD.

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