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Review Article

Attentional processes in posttraumatic stress disorder and the associated changes in neural functioning

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ABSTRACT

Posttraumatic Stress Disorder (PTSD) is associated with alterations in attention at the behavioral and neural levels. However, there are conflicting findings regarding the specific type of attention impairments present in PTSD, as the commonly used tests of attention do not isolate the mechanisms behind attention abnormalities, and the constructs measured do not map onto the neurocircuits governing attention. Here, we review the literature on attention processing in PTSD and offer directions for future research to clarify these unanswered questions. First, using instruments that allow assessment of behavioral and neurophysiological attention components will be necessary to understand attention deficits in PTSD. Second, focus on intra-individual variability in addition to assessment of central tendency may help clarify some of the mixed findings. Third, longitudinal studies on attentional processes are warranted to determine how attention contributes to the development and maintenance of PTSD. Integration of behavioral and neural measures of attention will be useful in understanding the pathophysiology of PTSD.

Contents

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1. Introduction

The fact that 70% of the US population will experience a traumatic event in their lifetime is a sobering thought (Posttraumatic Stress Disorder (PTSD) Alliance, 2000). While many people recover from such experiences, up to 20% of people who experience a traumatic event develop Posttraumatic Stress Disorder (PTSD) (Posttraumatic Stress Disorder (PTSD) Alliance, 2000), a disorder characterized by intrusive thoughts, hyperarousal, avoidance, and emotional numbing (American Psychiatric Association, 2013), suggesting that there may be risk factors that make some more vulnerable to PTSD development following trauma exposure. While there are evidence-based treatments for PTSD, these are only effective in some individuals, while partially effective, not effective, or not accessible to others (Connor et al., 1999; Disorder, 2014; Hembree et al., 2003; Ipser et al., 2006). Thus, there is a great need to find new ways to provide better treatment for PTSD. Studying the neurobiological and cognitive processes associated with PTSD may help elucidate etiological risk factors and assist with the development of effective therapies. In particular, studying the role of attention in PTSD development carries great promise, as attention is a critical component of emotion regulation (Ochsner and Gross, 2005), a process that is dysregulated in PTSD (Frewen and Lanius, 2006).

Many independent lines of investigation have implicated attention abnormalities in PTSD. First and foremost, patients with PTSD describe symptoms of hyperarousal, concentration difficulties, and intrusive thoughts (American Psychiatric Association, 2013; VanElzakker, 2015), all of which may be related to attention abnormalities. For example, PTSD patients frequently report lapses of attention, difficulty focusing and becoming distracted (Lew, 2011). Second, there is high comorbidity between PTSD and Attention Deficit Hyperactivity Disorder (ADHD) (Spencer and Faraone, 2015). Third, PTSD patients display altered attention biases towards emotional stimuli (Pineles and Shipherd, 2009). Fourth, PTSD subjects have altered performance on neuropsychological tests of attention (Aupperle et al., 2012; Polak et al., 2012a; Qureshi et al., 2011). Finally, our lab among others, has found differences in neural networks related to attention in PTSD (Daniels et al., 2013; Sripada et al., 2012a,b; Brown et al., 2014; Zhang et al., 2015; Zhang et al., 2016).

There are also substantial conceptual and methodological gaps between the basic and the clinical research on attention in PTSD. First, there are conflicting research findings regarding the specific type of attention impairments present in PTSD, as neuropsychological tests commonly used in clinical settings do not isolate the physiological mechanisms behind attention abnormalities, and the constructs measured do not map onto the neurocircuits governing attention (Petersen and Posner, 2012). Second, key components of attention functioning might be left unaddressed by studies ignoring intra-individual variability in attention, a measure which has been shown to be more reflective of attention deficits than measures of central tendency such as mean reaction time (RT) and accuracy (Lew, 2011). Third and finally, it remains unclear whether attention deficits are a risk factor or a consequence of the disorder. We have developed a program of research investigating the attentional processes in PTSD and associated changes in the underlying neural circuitry. Integrating these multiple lines of research may contribute to our understanding of the development and treatment of PTSD.

2. What is attention?

According to William James(1890),

"Everyone knows what attention is. It is taking possession of the mind in clear and vivid form of one out of what seem several simultaneous objects of trains of thought (pp. 381–382)."

While it may seem obvious what attention is, there are strikingly different definitions in the literature. The first set of definitions stems from the neuropsychology literature, while the second stems from the cognitive neuroscience literature.

Neuropsychology attempts to understand the relationship between behavioral impairments and brain disturbances using a battery of non-invasive tests. Interest in establishing these relationships began in the 19th century when Paul Broca and Carl Wernicke, who were working with language impaired patients, identified specific areas of brain damage in these patients postmortem (Shallice, 1988). However, examining the brain postmortem is rarely feasible. Thus, tests developed by neuropsychologists have been a valiant effort to understand neurobiological processes underlying behavior without directly observing the brain itself. From this, largely functional and essentially hypothetical categories of attention have been postulated, which are still used in clinical neuropsychology today. In this domain (Sohlberg and Mateer, 1989), attention is categorized as focused (directing attention to one input) and divided (focusing on multiple inputs simultaneously). Focused attention is further categorized as sustained (attending to one specific task for a continuous period of time), selective (focusing on one task while filtering out distractions) and alternating attention (switching focus back and forth between tasks with different demands).

While these distinctions appear to have face validity, they have not been shown to have distinct neurobiological underpinnings as once assumed. According to Patterson and Plaut, neuropsychology "has yielded relatively little advance in understanding how the brain accomplishes its cognitive business" (Patterson and Plaut, 2009, p. 39). Newer research in cognitive psychology, has, however, established a model of attention that more closely maps neural functioning. According to Posner and Petersen (1990) attention consists of three components: alerting (maintaining a state of vigilance and attending to novel stimuli), orienting (shifting and focusing on a subset of inputs) and conflict monitoring/executive attention (attention to and resolving incongruent stimuli). Roughly speaking, sustained attention in neuropsychology nomenclature may be thought of as similar to what Posner calls alerting attention, while selective attention may be thought of as similar to what Posner calls orienting attention; however, depending on the object of focus, the clinical components of attention may involve any or all of Posner's components. For example sustaining one's attention on a task for a long period of time may require vigilance, repeatedly shifting and attention as distractions arise, and conflict monitoring to detect the stimuli of interest while ignoring the rest. While alerting is considered to be a stimulus-driven, bottom-up process, meaning that it is automatic and reflexive, orienting attention is thought to be top-down, and volitional (Corbetta and Shulman, 2002). Either of these may be overt (involving a shift of the eyes) or covert (without eye shifting) (Fan and Posner, 2004). Subsequent studies have suggested that these three components likely have distinct neuroanatomy (Petersen and Posner, 2012) that will be discussed in detail in the next section.

3. Neural circuitry of attention

Functional magnetic resonance imaging (fMRI) studies suggest that the brain might be organized into multiple distinct intrinsic connectivity networks (ICNs), groups of brain regions (Fig. 1), whose low