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Do EMDR eye movements' worsen reactivation of visual stimuli and improve reactivation of verbal stimuli?

¿Los movimientos oculares del EMDR empeoran la reactivación de los estímulos visuales y mejoran la reactivación de los estímulos verbales?

Sánchez Beisel, Jessica Mariel [1*]; Andreau, Jorge Mario[1]

[1] Instituto de Investigación. Facultad de Psicología y Psicopedagogía. Universidad del Salvador, Buenos Aires, Argentina.

INFORMACION

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A B S T R A C T

The Dual Representation Theory of Post-Traumatic Stress Disorder (PTSD) suggests that traumatic memories have verbal and non-verbal components, with flashbacks characterized by sensory and non-verbal content. PTSD may affect memory recall, with individuals experiencing difficulty in verbal memory tasks and potentially having better performance in non-verbal ones. Additionally, several studies suggest that the reactivation of traumatic memories is often lateralized to the right hemisphere, which is associated with the reactivation of visual memories. On the other hand, verbal stimuli recall tends to activate the left hemisphere, which is associated with the reactivation of verbal memories. Eye Movement Desensitization and Reprocessing (EMDR), a therapy for PTSD, uses horizontal eye movements during memory reactivation to modulate patients' memories. How eye movements interact with memory is still unclear. Some studies show that eye movements reduce the vividness of visual stimuli whereas other studies report that eye movements enhance memory retrieval for verbal stimuli. We proposed a new hypothesis to explain the effect of eye movements on the reactivation of memory. We posit that there could be a differential effect of eye movements in memory based on the type of stimuli, improving recall for verbal stimuli but potentially worsening it for visual stimuli. The Dual Representation Theory of PTSD and clinical observations support this hypothesis. However, there is currently a lack of studies evaluating the impact of eye movements on memory reactivation with different stimuli. Further research is needed to explore this hypothesis and provide evidence on the differential effect of eye movements.

Keywords:
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Estímulos visuales
Estímulos verbales

R E S U M E N

La Teoría de Representación Dual del Trastorno de Estrés Postraumático (TEPT) sugiere que los recuerdos traumáticos tienen componentes verbales y no verbales, con los recuerdos vívidos caracterizados por contenido sensorial y no verbal. El TEPT puede afectar la recuperación de la memoria, con individuos que experimentan dificultad en tareas de memoria verbal y, potencialmente, un mejor rendimiento en tareas no verbales. Además, varios estudios sugieren que la reactivación de los recuerdos traumáticos se lateraliza con frecuencia hacia el hemisferio derecho, el cual está asociado con la reactivación de recuerdos visuales. Por otro lado, el recuerdo de estímulos verbales tiende a activar el hemisferio izquierdo, el cual está relacionado con la reactivación de recuerdos verbales. La Desensibilización y Reprocesamiento por Movimiento Ocular (EMDR, por sus siglas en inglés), una terapia para el TEPT, utiliza movimientos oculares horizontales durante la reactivación de recuerdos para modular los recuerdos de los pacientes. Cómo los movimientos oculares interactúan con la memoria sigue siendo incierto. Algunos estudios muestran que los movimientos oculares reducen la vividez de los estímulos visuales, mientras que otros reportan que los movimientos oculares mejoran la recuperación de recuerdos verbales. Proponemos una nueva hipótesis para explicar el efecto de los movimientos oculares sobre la reactivación de la memoria. Sostenemos que podría haber un efecto diferencial de los movimientos oculares en la memoria según el tipo de estímulo, mejorando el recuerdo de estímulos verbales pero potencialmente empeorándolo para estímulos visuales. La Teoría de Representación Dual del TEPT y las observaciones clínicas respaldan esta hipótesis. Sin embargo, actualmente existe una falta de estudios que evalúen el impacto de los movimientos oculares sobre la reactivación de la memoria con diferentes estímulos. Se necesita más investigación para explorar esta hipótesis y proporcionar evidencia sobre el efecto diferencial de los movimientos oculares.

*Dirección de e-mail del autor
jessica.beisel@usal.edu.ar

Post Traumatic Stress Disorder and Dual Representation Theory

Post-Traumatic Stress Disorder (PTSD) is a mental health disorder classified within the group of trauma-related disorders and stress-related factors in accordance with DSM-5 (American Psychiatric Association, 2014). A necessary criterion for making this diagnosis is the direct exposure to death, serious injury, or sexual violence, as well as a threat to any of these. Additionally, one or more of the following symptoms must be present: involuntary and intrusive recollections of the traumatic event or "flashbacks," distressing and recurrent dreams about the traumatic event, dissociative reactions, psychological distress, and intense physiological reactions triggered by contextual or internal cues associated with the traumatic event, avoidance behaviors, heightened alertness, and hyper-vigilance, sleep disturbances, irritability, and cognitive alterations in mood.

Within the diagnostic criteria for PTSD that affect memory, the presence of involuntary and intrusive recollections of the traumatic event and the inability to recall episodic aspects of the traumatic event (dissociative amnesia) are included (American Psychiatric Association, 2014). The intrusive memories or "flashbacks" are characteristic of PTSD and manifest rapidly and spontaneously in consciousness (Holmes & Bourne, 2008). They are typically highly sensory, accompanied by a high level of physiological activation, and experienced as a reenactment of the original traumatic event (Brewin *et al.*, 1996).

According to the Dual Representation Theory of PTSD (Brewin *et al.*, 1996), traumatic situations generates memories that possess at least two clearly distinguishable characteristics: one is of a verbal nature (e.g., *"I was driving my brother home, and when I crossed an intersection, the vehicle was hit by a truck that ran a red light"*), thus accessible to conscious awareness, and the other is of a non-verbal nature (e.g., the image of a bright, blinding light approaching, followed by a loud crash and the image of blood and smoke with a burnt smell), automatically accessible and often leading to intrusive memories or flashbacks (Brewin *et al.*, 1996). This latter type of memories consists of sensory information (mainly in the form of images; van der Kolk & Fisler, 1995) and bodily responses (e.g., if a person got stuck during a car accident, they may recall only the sensation of pressure on their legs preventing movement), but it does not necessarily use a verbal code (Brewin, 2001). In other words, the verbal components that would allow contextualizing the traumatic scene in time and space are not evoked (in the case of being able to verbalize it, the patient should say something like *"I remember that this was the feeling of pressure I had when, after the accident two years ago, I couldn't get out of the car because it was crushed by the impact, and I was trapped until I was rescued, but it doesn't correspond to a pressure or blockage that prevents me from moving currently"*).

According to Brewin (2001) y Brewin *et al.*, 1996), these are two distinct memory systems with different effects based on the stress caused by the traumatic situation. The re-experiencing of traumatic events is different from the evocation of other types of memories, such as autobiographical memories (van der Kolk & Fisler, 1995). This is because the evocation of autobiographical memories is retrieved with verbal content, while flashbacks are retrieved with sensory content and without verbal content. In fact, intrusive memories or flashbacks occur spontaneously based on the detection of external and internal cues associated with the traumatic situation, and they cannot be controlled. They are characterized by extreme sensory vividness (e.g., having a backpack on one's legs and feeling the same pressure that was felt during the accident, as if experiencing that pressure and inability to move at the present moment). On the contrary, in ordinary autobiographical memories, sensory elements are integrated into an episodic narration of the event (van der Kolk & McFarlane, 1996).

Coinciding with the proposal of the dual representation of PTSD (Paivio, 1990) established that affective and emotional reactions are dual-coded, initially associated with a non-verbal representational system due to their learning occurring in a context of non-verbal events.

According to the conclusions of a meta-analysis study on the memory performance of neutral stimuli in individuals with PTSD, they tend to have poorer performance in verbal memory tasks than in non-verbal ones (Brewin *et al.*, 2007). This finding could align with what is proposed by the Dual Representation Theory of PTSD (Brewin *et al.*, 1996) regarding the differential effect of traumatic stress on different types of memories. Furthermore, thedecrease in the recall of verbal stimuli resembles the diagnostic criterion of dissociative amnesia in PTSD, while the evidence of better performance in the recall of non-verbal stimuli could be related to an exacerbation of the presence of non-verbalizable "flashbacks" in PTSD.

Evidence for possible hemispheric lateralization in traumatic memory coding

According to Brewin (2001), part of the traumatic memory would be encoded verbally in a hippocampus-dependent pathway. On the other hand, there would be a portion of the memory that is primarily perceptually encoded in the form of images, processed by a pathway independent of the hippocampus and composed of connections between the prefrontal cortex, the amygdala, and regions of the occipital cortex involved in visual processing. This would be the system responsible for the flashbacks.

Furthermore, at the level of general memory reactivation processing, some authors argue that the retrieval of visual stimuli would activate the right hemisphere to a greater extent, while the retrieval of verbal stimuli would activate the left hemisphere (Wagner *et al.*, 1998).

Next, we will review a series of studies that provide evidence about the existence of possible hemispheric lateralization in the dual encoding of traumatic memory.

On one hand, there is ample evidence that the reactivation of traumatic memories is lateralized to the right (Lanius *et al.*, 2004; Rabe *et al.*, 2008; Rauch *et al.*, 1996; Schiffer *et al.*, 1995; Teicher *et al.*, 1997). An electroencephalography study with event-related potentials in subjects with traumatic childhood history provided evidence that there is a left dominance asymmetry during the recall of neutral memories and a predominantly right asymmetry during the recall of traumatic memories (Schiffer *et al.*, 1995). Additionally, physical and sexual abuse suffered in childhood resulted in abnormalities in coherence measured by electroencephalography in the left frontotemporal region compared to individuals who did not experience abuse (Teicher *et al.*, 1997). These coherence differences were not observed in the right frontotemporal region, providing further evidence for the hypothesis of a right-sided asymmetry prevalence in memory retrieval in individuals who have experienced traumatic situations.

In an electroencephalography experiment with subjects with PTSD, a rightward lateralization of activation was observed during exposure to images related to the traumatic event. After a psychotherapeutic intervention, the reduction of traumatic symptomatology positively correlated with a decrease in right anterior areas during exposure to visual stimuli associated with trauma (Rabe *et al.*, 2008).

In a study using positron emission tomography, PTSD patients showed increased blood flow in right limbic, paralimbic, and visual areas when exposed to audio of their own traumatic memories. Conversely, a decrease in blood flow was observed in the left inferior frontal cortex and medial temporal cortex (Rauch *et al.*, 1996).

Furthermore, more information about this hemispheric asymmetry was found by demonstrating through a functional connectivity analysis that rightward lateralization can be observed in individuals who experienced traumatic situations and developed

PTSD, while it is not observed in subjects who had traumatic experiences but did not develop symptoms of this disorder (Lanius *et al.*, 2004). In individuals who "overcame" the trauma by not developing PTSD, brain areas associated with the reactivation of verbal memories are activated when they recall the traumatic event, such as the left superior frontal gyrus and the left anterior cingulate gyrus. In contrast, in subjects who did develop PTSD, areas of non-verbal memory reactivation are activated, such as the right posterior cingulate gyrus and the right parietal and occipital lobes. This rightward lateralization was observed only for the reactivation of traumatic memories and not for the reactivation of non-traumatic autobiographical memories.

On the other hand, we propose that the evidence suggests a left lateralization for the recall of verbal stimuli (Adenauer *et al.*, 2011; Lanius *et al.*, 2004). Regarding general processing, a positron emission tomography study on verbal processing showed unilateral activation of the left dorsolateral prefrontal cortex (Frith *et al.*, 1991). Another study using the same technique that confirmed this activation also analyzed different types of verbal processing and concluded that the left inferior prefrontal cortex is the anatomical region involved in processing "with meaning" (Kapur *et al.*, 1994).

As for the encoding of potentially traumatic experiences in individuals who do not develop PTSD symptoms, the left lateralization observed in individuals who experienced trauma but did not develop PTSD mentioned above (Lanius *et al.*, 2004) aligns with forms of verbal processing. Additionally, in some individuals who go through a traumatic experience, there may be an inability to recall episodic aspects of the memory (dissociative amnesia) (American Psychiatric Association, 2014).

Under conditions of extreme stress, there may be failures in memory processing in the hippocampus, leading to an inability to integrate sensory elements of the memory into a coherent autobiographical narrative, leaving the sensory elements of the experience disintegrated (van der Kolk *et al.*, 2001). A therapeutic tool for this problem is the narrative creation of a biographical timeline with positive and negative events, allowing the traumatic memory to be incorporated verbally and narrated within an episodic temporality (Narrative Exposure Therapy). Processing trauma within the autobiography through narrative exposure leads to a significant reduction in traumatic symptoms (Cáceres Rubio & Crespo López, 2019), whereas an inability to remember an important aspect of the trauma increases traumatic symptoms. Therefore, it is essential to assess the improvement of verbal components of memory generated by the treatment. One study revealed increased activation of left lateralized posterior areas after Narrative Exposure Therapy (NET), which aligns with activation of verbally mediated processes (Adenauer *et al.*, 2011).

Eye Movement Desensitization and Reprocessing (EMDR)

Eye Movement Desensitization and Reprocessing Therapy (EMDR) utilizes horizontal eye movements to modulate the memories of patients with PTSD (Shapiro, 2018). It consists of an eight-phase treatment (clinical history, preparation, assessment, desensitization, installation of positive cognitions, body scan, and reevaluation). Within the desensitization phase, bilateral stimulation is repeatedly applied (e.g., saccadic eye movements), along with the reactivation of different aspects of the traumatic memory until the subjective distress associated with this memory significantly decreases. This helps, among other things, to improve episodic aspects of the memory and reduce levels of emotional intensity associated with it (Novo Navarro *et al.*, 2018).

The initial description of EMDR included eye movements as a central component, but later on, other forms of bilateral stimulation were incorporated, such as auditory stimulation and tapping, which involves alternating taps with or on the hands or fingers. However, bilateral auditory stimulation has a lesser effect compared to eye movements (van den Hout *et al.*, 2012; van den Hout *et al.*, 2011). Regarding tapping, a study examined the efficacy of EMDR with eye movements, using thumb tapping as one of the control groups, and found that EMDR therapy was effective only in the group that performed eye movements (Wilson *et al.*, 1996). In a study involving autobiographical memories, the effect of eye movements on the level of vividness and emotional intensity of memories was analyzed. The reactivation of these memories combined with eye movements showed a lower level of vividness and emotional intensity compared to groups that performed finger tapping or no task at all (van den Hout *et al.*, 2001).

Conversely, there is evidence supporting the effectiveness of eye movements in reducing the vividness and emotional intensity of memories (Engelhard *et al.*, 2011; Kavanagh *et al.*, 2001; van Schie *et al.*, 2019). In conclusion, eye movements are important for the efficacy of EMDR therapy (Jeffries & Davis, 2013).

Currently, there is no consensus on why EMDR therapy works, although experimental studies on eye movements have been conducted with different hypotheses and results.

Could there be a differential effect of EMDR on memory depending on the type of stimulus?

One of the characteristics of EMDR therapy is that its success depends on the dysfunctional encoded information being successfully integrated into memory networks, which involves higher levels of verbal integration of a memory that was initially encoded in the form of images (Shapiro, 2018).

Taking into account the theoretical proposal of the dual representation model of PTSD (Brewin *et al.*, 1996), the results of behavioral studies (Brewin *et al.*, 2007), psychophysiological, and neuroimaging studies (Lanius *et al.*, 2004; Rabe *et al.*, 2008; Rauch *et al.*, 1996; Schiffer *et al.*, 1995; Teicher *et al.*, 1997) on the relationship between PTSD and memory; and the notion that individuals who develop PTSD may have a tendency to reactivate primarily visual components of the traumatic memory while experiencing difficulties in reactivating its verbal characteristics; we aimed to assess whether studies on memory and eye movements reveal differences in the effect depending on the type of stimulus.

In one of the early studies on the effect of eye movements (Andrade *et al.*, 1997), they assessed the impact of performing eye movements on levels of vividness and emotionality while reactivating negative and neutral images. They used black and white newspaper images: negative images (e.g., wars, death, and disasters) and neutral images (e.g., animals or people in positive or neutral contexts). They found that the group that performed eye movements during the reactivation of the images rated both negative and neutral images as less vivid compared to a control group that only received alternating visual stimulation at the center of the screen. These results were replicated in a second experiment that included a control group performing a counting task as a dual task. Only the subjects who performed eye movements showed a significant difference in the vividness score of the images. Regarding emotionality, the results were inconclusive as the eye movement group differed from the counting group but not from the control group, making the results inconsistent in this aspect. The results of experiments 1 and 2 show that not any dual task generates an effect, but rather performing eye movements was more effective, at least for visual stimuli. While this study demonstrated that eye movements have an effect on emotional visual stimuli, it does not describe what happens with memory, whether it improves or worsens, considering the valence of the stimulus. Similar results regarding the effect of eye movements in reducing vividness were found in a study that used two neutral paintings with many details as visual stimuli: a scene of New York City and a scene of a kitchen. They observed that in the group that performed eye movements together with the reactivation of the memory of one of the paintings, the level of vividness significantly decreased compared to the control group that had to keep their gaze fixed on a point on the screen and compared to the painting whose memory was not reactivated (van den Hout *et al*., 2013).

The effect of eye movements on the recall of verbal stimuli has mainly been explored through the SIRE (Saccade Induced Retrieval Enhancement) effect. According to this hypothesis, performing horizontal eye movements before the reactivation of autobiographical and verbal memories (mainly word lists) has been shown to improve memory retrieval (Christman *et al*., 2003, 2004). The authors argue that this effect is due to EMDR modulating memory by increasing communication between both cerebral hemispheres (Christman & Propper, 2001), and they provided evidence from an electroencephalography study showing that eye movements lead to a decrease in interhemispheric gamma coherence in the anterior prefrontal cortex (Propper *et al*., 2007). However, in this latter study, participants were not required to think about anything or recall a memory while performing the eye movements, so the effect of eye movements on memory recall was not assessed. A more recent study that evaluated the effect of eye movements on both interhemispheric coherence and memory retrieval did not find results to support the hypothesis of interhemispheric coherence. Therefore, they did not find psychophysiological evidence from electroencephalography that eye movements altered interhemispheric coherence or that memory improvement was related to changes in coherence (Samara *et al*., 2011). Despite these results, some studies have failed to replicate the SIRE effect (Roberts *et al*., 2020), leading some authors to argue that this effect cannot be replicated due to experimental errors in the pioneering SIRE studies and that it does not exist (Matzke *et al*., 2015). However, we consider that a reason that could weaken this effect and, therefore, make it less replicable, could be the valence of the stimuli to be recalled. In this regard, only two studies have explored the effect of eye movements and evaluated their impact on the recall of emotional verbal stimuli. One of them (Samara *et al*., 2011) focused on the analysis of the effect of eye movements on interhemispheric coherence using electroencephalography and used emotional and neutral words as stimuli. The results showed that there was an improvement in the recall of emotional words for the group that performed eye movements before a free recall test compared to a control group that observed a color-changing circle in the center of the screen. This memory enhancement was not observed for neutral words, thus not replicating previous studies on the SIRE effect (Christman *et al*., 2003, 2004; Christman & Propper, 2001), but it could be inferred that this effect did occur for emotional words. In another study, in line with the SIRE hypothesis, an increase in memory evaluation was observed after performing eye movements compared to a control group that observed a color-changing cross in the center of the screen (Phaf, 2017). The stimuli used were positive, neutral and negative words. The memory enhancement effect was more pronounced for negative words than for neutral and positive words and was stronger in strictly right-handed subjects.

Is the effect of eye movements detrimental for visual stimuli and beneficial for verbal stimuli?

Those studies that have observed a deterioration in memory due to eye movements (reviewed in Sánchez Beisel *et al*., 2020) have not evaluated memory performance but other characteristics such as emotional intensity and vividness. Also, the studies that have observed memory improvement due to eye movements have mainly focused on verbal stimuli (Christman *et al*., 2003, 2004), we hypothesize that eye movements may worsen the reactivation of visual stimuli while improving the reactivation of verbal stimuli. In this way, the effect of eye movements during memory reactivation would differ according to the type of stimulus, facilitating the reactivation of verbal stimuli while showing a detrimental effect for visual stimuli. This hypothesis aligns with clinical observations following EMDR application, where a more adaptive integration of the traumatic event's narrative into memory networks is observed, involving both the verbal and sensory-visual memory systems proposed by the Dual Representation Theory of PTSD (Lescano, 2022).

Currently, there are no studies found that evaluate the effect of eye movements on memory reactivation and whether there are differences depending on the type of stimulus. Although this hypothesis makes theoretical sense, behavioral studies on the effect of eye movements on the reactivation of visual and verbal stimuli should be conducted to test it and evaluate the data provided by the evidence. To conclude, we will describe a recent single-case study whose results align with the hypotheses of hemispheric lateralization of traumatic memory and the differential effect of eye movements according to the type of stimulus. In order to test the feasibility of electroencephalographic analysis during eye movements, to evaluate whether it is possible to conduct a study on the neurophysiological correlates of bilateral EMDR stimulation with greater temporal precision than functional magnetic resonance imaging provides, Pagani and colleagues conducted a preliminary single-case study using electroencephalography (Pagani *et al*., 2011). This study was the first to record physiological data at the exact moment when a patient with PTSD was reactivating a traumatic autobiographical memory while simultaneously performing eye movements. Although this study was conducted with a single case, it stands out for having followed the entire EMDR protocol, including all eight phases of treatment. The study recorded electroencephalographic data while the patient listened to her own traumatic memory and while mentally reactivating it in conjunction with performing eye movements. These two measures were taken at the beginning of the second session (pre-treatment measurement) and at the beginning of the fourth and final session (post-treatment measurement). To remove noise from the signal produced by blinking and eye movements, an independent component analysis was conducted. The results found activation of the prefrontal cortex as a result of bilateral stimulation. Surprisingly, results suggested that there is a trend for lateralization of orbitofrontal prefrontal cortex activation during eye movements to shift from mainly right-lateralized at the beginning of treatment to left-lateralized at the end of treatment. During the second session, eye movements were associated with greater right-lateralized activation compared to greater left-lateralized activation during the last session. In conclusion, this preliminary single-case study was conducted using electroencephalography throughout the complete EMDR treatment process, showing a tendency of prefrontal cortex lateralization towards the left after bilateral stimulation with eye movements (Pagani *et al.*, 2011), particularly in the beta and gamma frequency bands. However, further research with larger experimental samples is necessary to expand this investigation and to provide more evidence to the hypothesis about a differential effect of eye movements according to the type of stimuli.

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