DEFICITS IN IMPLICIT CONTEXTUAL MEMORY IN POSTTRAUMATIC STRESS DISORDER PATIENTS

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1. PROCESO CONCEPTUAL
Pertinencia, claridad, profundidad y uso de los fundamentos teóricos utilizados, manejo de conceptos, coherencia de las teorías con relación al tema específico y a la problemática escogida.

5.0 5.0

2. PROCESO METODOLOGICO
Proceso de explicación – comprensión: recolección de información (uso de fuentes, elaboración de instrumentos, proceso participativo y recursividad), Sistematización y formalización (datos, hechos, Normas APA, criterios), Proceso de análisis e interpretación, coherencia, Pertinencia y uso de la metodología empleada así como las herramientas utilizadas.

5.0 5.0

3. PROCESO FORMAL
Manejo y organización del discurso, Coherencia entre capítulos, redacción, referencias bibliográficas, presentación, secuencias, anexos, índices según metodología APA.

4.5 4.5

El informe se califica de acuerdo con la siguiente escala y criterios de evaluación

	Nota
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Resumen

Anteriores investigaciones han explorado la profunda relación existente entre el hipocampo y la memoria contextual implícita, al igual que han descubierto que esta estructura está implicada negativamente en el trastorno por estrés postraumático. No obstante, es necesaria evidencia que conecte la memoria contextual implícita con este desorden. Mediante el Contextual Cueing Task, esta investigación ha permitido determinar que las personas con esta patología poseen un déficit en el aprendizaje contextual implícito, debido a que no son capaces de diferenciar entre los antiguos y repetidos displays de la tarea. Aunque este estudio fue realizado con una muestra limitada de participantes, los resultados encontrados abren una gama de posibilidades para mantenerse explorando en este ámbito, con la posibilidad de incluir un mayor número de participantes y añadiendo neuroimágenes que permitan evidenciar el déficit hipocampal mientras se completa la tarea que involucra la memoria implícita contextual.

Introduction

In Colombia the post-traumatic stress disorder (PTSD) has become of great interest due to the internal conflict army that the country has lived for more than fifty years, which have increased the cases of this diagnostic.

The PTSD is mental health disorder which involves unique characteristics because of its cause and symptoms. For its appearance it is necessary the exposure to a traumatic event and the presence of intense fear, hyperarousal, irritability, among others, for longer than three months. A person who suffer this illness remember the episode just with the presence of one stimulus and present the same fear reaction as that day (APA, 2000).

Essentially, this means that contexts play an important role in PTSD. Context can be defined as the sum of conditions which are made by long- term associations and they give significance to the environment by defining and representing it (Aminoff, Kveraga & Bar, 2013). Studies have revealed that this kind of information is encoded in the hippocampus because it is in charge of remembering explicit and implicit memories. Previously, the hippocampus was only related with the declarative memory, but thanks to the Contextual Cueing Task, it was possible to discover that the hippocampus has also other important functions as contextual implicit memory, which means the capacity to acquire contextual information from the surroundings without conscious awareness (Greene et al., 2007). Thus, findings have determined that a hippocampus irregularity produce difficulties in creating contextual representations. Structural and functional magnetic resonance imaging (MRI) in PTSD hippocampus were analyzed to find possible impairments, detecting that this structure has less gray matter (Kitayama et al., 2006) and abnormal metabolic activity in this mental disorder (Shin et al., 2009).

This information suggests a connection between contextual implicit memory and PTSD, because if it exists a deficit in the hippocampal volume, the patients are not able to associate the elements of the whole context, they will do it separately. Rudy (2009), Brewin et al. (2010) planted models that explained the way memories are represented in PTSD subjects brain. They affirmed that healthy people create a whole memory of an event, including all spatial representations, fear and panic responses. Conversely, PTSD subjects cannot join all the elements of a context with the emotion, so when a single stimulus of the event appears, fear and panic reactions are activated. This data means that it also exists difficulties in contextual fear conditioning, defined as a learning in which a context stimuli is associated with an aversive consequence and the hippocampus along with the amygdala are the main structures in charge of this function. Thus, a hippocampal disruption generates an impairment of correct associations among a fear response and the stimulus which cause it (Álvarez et al., 2008).

Based on the previous background, here we evidence if the involvement of the contextual implicit memory is impaired in PTSD subjects. The results can be linked with the hippocampal investigations and therefore, it is possible to establish a connection among the contextual implicit memory, the hippocampus and PTSD.

Statement of the problem

The contextual cueing task has permitted to prove the hypothesis that contextual memory is involved in the hippocampus functions. On the other hand, structural MRI and functional MRI studies have revealed that there is hypoactivation and reduced volume of the hippocampus in PTSD patients. This disorder is characterized by presenting flashbacks of a traumatic event, arousal activation and avoidance of people, activities or places related to the circumstance. Taking that into account, Brewin (2010) and Rudy's model (2009) have explained the connection between the context and what happens with PTSD patients. It is explained by mentioning that the brain of PTSD encodes elements separately, instead of joining them as one. As consequence of this evidence it is necessary to investigate if contextual information is affected negatively in patients with PTSD.

Research question

Are the encoding and expression of the contextual information affected negatively in patients with PTSD?

Hypothesis

H1: Implicit contextual learning is impaired in PTSD subjects but not in control subjects

H0: Implicit contextual learning is not impaired in PTSD.

Justification

It is known that the worst traumatic event is called the war, because it is considered the most violent act produced by the human being. Numerous of them have been reported along the history but two of them, led 1’478.000 deaths, the Korean War and Vietnam War which were important for the PSTD investigation and advances. These events produced too many cases of veterans that suffered deep symptoms of this disorder. In response to this situation and the high medical demand, it was necessary to coin the term PTSD (Alarcon, 2007).Between the end of the Second World War and 1990, 127 wars were counted. 60’000.000 persons were killed in the world wars. Nowadays, the World Health Organization (WHO) estimates that 3.6% of the world's population has suffered a post-traumatic stress disorder (PTSD) in the last year (WHO, 2013). Other investigations as the one leaded in Madrid, showed that 2.3% people developed PTSD from terrorist attacks (Miguel-Tobal, Cano, Iruarrízaga, González & Galea, 2004). Particularly, Colombia has lived an internal conflict for 60 years. This battle born because of different political ideas, but it has lost its meaning, using violence and forced displacement. 350.000 deaths has been counted until today. National investigations developed in Colombia revealed that the prevalence of PTSD once in live is 1%, the prevalence of 12 months is 0, 5% and of 30 days 0, 2% (Posada-Villa, Aguilar-Gaxiola, Magaña & Gómez, 2003). Another study done in Chocó exposed that a year after a specific traumatic in this region generated that 37% of 40 participants develop PTSD (Londoño, Muñiz, Correa, Patiño & Jaramillo, 2005). In addition, a research completed in a Cartagena’s neighborhood with displaced population found that 70% of them reported symptom of the PTSD (Cáceres, Izquierdo-Mantilla, Blandía, González & Jara, 2001). Due to this circumstance have been impregnated in the life of all Colombians, it is considered a theme of national interest. As a consequence the Ministry of Health and Social

Protection and Colciencias, effectuated National Mental Health Survey with the objective of knowing and delimiting public policies that helps mental health in Colombia.

According to our knowledge, there are not enough investigations in Colombian PTSD patients. Particularly, it is important to understand the process that develop and maintain this disorder and indirectly improve the quality of life.

Objectives

General Objective

To determine if PTSD subjects have deficits in implicit contextual learning.

Specific Objectives

Obtaining and analyzing Contextual Cueing Task RT's in PTSD subjects and control subjects.

Obtaining and analyzing Contextual Cueing Effect in PTSD patients and control subjects and to examine possible differences between them.

Background

Chun and Phelps (1999) wanted to prove if subjects who had hippocampal damage could solve tasks that involved implicit contextual memory. For this purpose, they investigated 4 amnesic people (MRI confirmed hippocampus damage) and 15 control subjects by using a contextual cueing task that measured implicit memory. This experiment consisted on locating a T target (which can be rotated) between also rotated L distractors it included twenty blocks of twenty four trials. Half of the trials were all displays and the other were new ones. All displays conserved same locations while the new ones have variant contexts. Results showed that reaction time in the control subjects decreased with time, exhibiting that their performance was quicklier when old displays were detected. Because the amnesic patients couldn't have contextual learning, their performance was slower than the control group. The authors determined that amnesic patients (hippocampus damage) have difficulties on implicit contextual learning, which means encoding relational information without conscious memory processes.

Another study had as objective to prove if the implicit memory was impaired in people with anterograde amnesia (Park, Quinlan, Thornton, & Reder, 2004). This investigation studied the effect of Midazolam and saline in healthy people. The Midazolam is a type of benzodiazepine which can cause amnesia on encoding information by promoting the production of GABA. This neurotransmitter has inhibitory functions. The body can process it without much trouble and does not cause difficulties in other cognitive functions. Various studies had showed that Midazolam can disturb the explicit memory but few that it affected also the implicit tasks (Polster, McCarthy, O'Sullivan & Park, 1993). The experiment consisted on an implicit visual search task which participants had to perform twice under the effects of Midazolam and Saline. Results showed that people involve drug condition had a general improvement in search performance. But they were under the saline effects it appear facilitations for the old displays.

The study supports that amnesic people have difficulties on creating new associations between elements, which means that they have complications on generating contextual memories. By the other hand, even if they are amnesiacs, the search performance decreased over time, therefore, they have the ability to skill (motor) learning (Park, Quinlan, Thornton, & Reder. 2004).

Ruben Álvarez et al. (2008) Studied contextual fear conditioning in animals as rodents to identify which brain structures and networks are involved. The evidence demonstrated that the amygdala and the hippocampus are the ones with greatest activity. In addition, it was discovered that there are pathways connected with regions as the orbitofrontal cortex that are important for context information. However, there was not enough research in humans that studied the contextual fear conditioning, for that reason, this study planted the hypothesis that, in humans, the context conditioning activates network of regions that include the amygdala, hippocampus and orbitofrontal cortex. This research included 13 participants in healthy conditions. Virtual reality was used to produce two environments (contexts): A house and airport. One of them was selected to be conditioned with the presence of unconditional stimulus that was a foot shock and the other one did not presented any shock. During the conditioning, fMRI, skin conductance and anxiety ratings were recorded. Results showed more electro dermal activity in the environment that was conditioned than the one without any stimulus. Also, the subjective reports of anxiety indicated that the rating was higher in conditioned environment than in the unconditioned. fMRI showed more brain activity in left posterior orbitofrontal, left medial dorsal thalamus, left anterior insula, left subgenual anterior cingulate and bilateral parahippocampal cortex when the shock context was shown. Concerning the amygdala and the hippocampus, blood oxygenation level dependent signal (BOLD) responses analysis showed greater activation in bilateral amygdala and in the right anterior hippocampus. According to the hypothesis mentioned at the beginning, this investigation affirmed that the right anterior hippocampus and the bilateral amygdala are deeply implicated in contextual fear conditioning. It also confirmed that there are other regions as the thalamus, the orbitofrontal and the parahippocampal regions connected directly with the amygdala (Alvarez, Biggs, Chen, Pine & Grillon, 2008). In short, this findings confirmed as other investigations that hippocampus and the amygdala are main structures in the contextual fear conditioning.

Thomas McHugh and Susumu Tonegawa (2009) proposed an experiment in animals to compare the contextual fear memory in normal mice and in mutants that were modified in their CA3 pyramidals cells. Their objective was to identify how the hippocampal contextual representations are formed in normal and modified mice. This proposal was born taking into account the previous theory that affirmed the hippocampus was in charge of encoding multiple stimulus, including the context and another extra like a tone. In addition, they declared that if the hippocampus had a disruption, another non-hippocampal circuits would be activated to compensate the hippocampal function. It is important to emphasize that although the non-hippocampal circuits make up its functions, it takes longer to create and memorize contextual representations. However, the authors of this research determine that the previous approach is valid in cases of neuro or excitotoxic lesions, but when pharmacological or genetic modifications are performed, the contextual fear learning is still executed in the hippocampus thanks to a plasticity in the speed and salience of the circuit that form contextual representation. Based on the results they established that the hippocampus can form contextual representations rapidly, and when its nature is modified, it can also complete the task, but it takes longer to achieve it (McHugh and Tonegawa, 2009).

As it has been said before, the hippocampus is a structure in charge of memory processing, and hence, it is deeply related with the amygdala because of the development of emotions in certain contexts. Furthermore, studies have confirmed that PTSD patients have difficulties in processing contextual representations due to an abnormality in there hippocampus. Based on this approaches, Wang et al. (2010) planted a case-control study to identify if specific subfields of the hippocampus were involved in the PTSD pathology. In this research they recruited 17 male veterans with PTSD and 19 male control subjects without PTSD, but who also presented a traumatic event (excepting five that never lived a traumatic exposure). The authors used MRI scans to identify the volume of hippocampal subfields as dentate gyrus, cornu ammonis, entorhinal cortex and subiculum. They also measured the total volume of the hippocampus and the total intracranial volume. Importantly they also considered the age as a factor that decrease the volume. They found that the intracranial volume is smaller in PTSD than in healthy controls. Talking about the subfields, they discover that the area CA3/DG is also smaller in PTSD subjects. By the other hand, they observed that the age did not affect the volume of the previous subfield, but it is connected with CA1 and CA1/2. The results also showed that there is an effect of PTSD and age in the whole hippocampal volume. As it is known, the stress is the main cause of the hippocampus dysfunction, specifically the subfield CA3/DG. Findings have proposed three main reasons: The first one mentions that there is a suppression of the neurogenesis that occurs in this area, and therefore, there is a volume reduction. Secondly, the excess of glucocorticoid is neurotoxic for the hippocampus and its exorbitant levels make cause a diminution of the dendritic branching. Ultimately, the decrement synaptic or neuronal plasticity is also an explanation of the volume loss. In conclusion, the authors determined that there are specific hippocampal areas implicated in the PTSD disorder (Wang et al., 2010).

Theoretical framework

The DSM IV-TR defines PTSD as a mental disorder caused by the exposure to a known environmental stimulus, life-threatening or traumatic event. People who suffer of this pathology have lived an experience that has put its live in danger or its physical integrity in risk. In addition, they answered to this fact with horror, panic or fear. Some symptoms that appear are hyperarousal, irritability, difficulty sleeping and increased reactivity (APA, 2000). This disorder causes significant dysfunctionality in the family, social and working context, because they respond to any stimulus that the memory consider as a threat with agitation. Consequently, they avoid having social relationships and any kind of experience which remind them the episode; they are most of the time irritable and angry, with insomnia and reactivity. The development of PTSD depends on different factors as gender, type of trauma, genetic factors and neurobiological markers which are subjects of discuss (APA, 2000).

Structural and functional MRI studies have shown that people who suffer PTSD have amygdala hyperactivation and less activity in the prefrontal cortex. This means that it exists an interference problem between two areas, because the prefrontal cortex cannot control the amygdala (Etkin & Wager, 2007). Besides, the Anterior Cingulate Cortex (ACC) plays an important role in the PTSD because studies have proved that it is considered a pre-existing vulnerability factor to acquire the disorder. Neuroimaging has exhibit that this structure has less gray matter (Kitayama et al., 2006) and abnormal metabolic activity (Shin et al., 2009). Fundamentally, it has been found that hippocampus is deeply affected in PTSD patients.

Hippocampus

This structure is considered critical for encoding and retrieving information. (Squire, Zola-Morgan, 1991). The hippocampus allows remembering conscious events and facts which are catalogue in a type of memory called declarative (Cohen & Squire, 1980). However, the hippocampus is an area that displays other functions as contextual memory, which belongs to the category of implicit memory defined as in charge of contextual, spatio-configural information (Hirsh, 1974).

Evidence of the implications between the hippocampus and contextual memory.

It exists lots of studies who have found an important role of the hippocampus in the declarative memory. Nevertheless, other experiments have been done to provide information that also confirms that the hippocampus is potentially related with unconscious memory. Greene et al. (2007), realized an investigation based on a test done by Chun & Jiang (1998), titled contextual cueing task. They wanted to examine with a FMRI the hippocampus activation to prove if it is working in a contextual task. The test consists on discovering a "T" between some distractors and indicated if it is pointing the right or the left side. Participants have to press specific letter of the keyboard. There are 20 blocks of trials, composed by 12 novel and 12 repeated. They are presented randomly. Each trail lasts three seconds and then a visual feedback of one second is presented. After that, participants did a recognition test in which they had to answer if they recognized the repeated trials.

The two variables taking into account were accuracy and reaction time. Results showed that the location of the repeated trials was faster that novel ones (Greene et al., 2007). Equally it is demonstrated that the facilitation is not increasing when the number of exposure also increased, which means that the facilitations on recognizing repeated trials did not depend on recognition but in unconscious learning. Results proved that hippocampal activation was more in novel trials than in the repeated ones. Also hippocampal activation is more when reaction time is less in repeated trials (Greene et al., 2007). These data supported the hypothesis that the hippocampus can recognize a difference repeated novel trials even if it is not conscious. This experiment reveal that there is a hippocampal activity differentiating novel and repeated trials, despite that the recognition test showed that the participant could not distinguish between them. This study has as a purpose to argue that the hippocampus has also other functions as contextual learning and not only the declarative memory (Greene et al., 2007). Based on the previous information it is possible to say that PTSD patients which have deficits in the hippocampus may have difficulties in the contextual learning.

Relationship between hippocampus and PTSD

Because patients with PTSD have problems with their memories about their traumatic event, the PTSD is associated with an abnormality in the hippocampus. Images have proved that the volume of the hippocampus is bilaterally reduced in comparison with healthy patients (Kitayama et al., 2005). Moreover, positron emission tomography (PET) that measure hippocampal regional cerebral blood flow has demonstrated that patients with PTSD have more activation of this area when a negative image is presented, but when an image related to the traumatic event is presented, there is an hypoactivation (Hayes et al., 2011). Theorists have created some explanations that link the hippocampus, the contextual memory and PTSD.

Brewin's model that explains the relation between hippocampus, contextual memory and PTSD.

Brewin et al. (2010) posed a model that describe why PTSD patients respond with inappropriate fear to any hint related with the trauma, even if the context does not have the whole elements of the experience. There are two types of memory that compose a mental representation of the event. (Brewin et al., 2010). C-reps are a memory that depends on the hippocampus and are related to the spatial context of an event. In contrast, S-reps are representations of the same event, but in terms of sensations and affective valence, associated with fear responses of the amygdala and insula. A healthy person that perceives an environmental stimulus activates an S-rep with its respective C-rep. (Brewin et al., 2010). This connection between memories allows an event to be put in a present context and to react in a correctly emotional way. What happens with PTSD is that they present strong S-reps but they don't have the corresponding C-reps because the hippocampus is not working correctly. This deficit causes that the person react as he was living the threatens again, so reactions as arousal and fear appear (Brewin et al., 2010).

Rudy model: An explanation of two ways given memories is represented in the brain.

The brain has two forms of encoding an experience. The first one encodes the elements that belong to a context in an individual way. This means that elements of the traumatic event are identified separately. Therefore, the appearance of a single element on a PTSD patient that recalls the traumatic event is seen as the whole presentation and context of the event, so the person reacts with fear (Rudy et al. 2004; Rudy, 2009). The second kind of encoding a memory is when the brain encodes individual elements as one single representation. In a person who has lived a trauma but didn't develop PTSD, is necessary the presence of all elements that match the total traumatic event. As a result this person would not react with fear to a given stimulus, because it requires spatial, temporal and context elements. It is known that the neocortex control the individual associations and the hippocampus the conjunctive associations (Rudy et al. 2004; Rudy, 2009). Patients with PTSD have hippocampal dysfunction which means that the strategies to make whole associations are not working well, so there is more capacities in learning singular memories.

Several studies in rats have shown that the hippocampus is deeply involved in learning contexts. In one experiment, a rat is exposed to a specific room in which a shock is given.

Findings show that when the rat is put it in the room, the animal start to exhibit behaviors related to fear. However, when the rat is exposed to the elements of the room but separately, it does not show fear. These results confirm that the whole context is needed to create fear learning (Rudy et al. 2004; Rudy, 2009). In addition other studies have supported that lesions in the hippocampus permit only elemental associations and not conjunctive ones.

Context and contextual memory

Context can be defined as the sum of conditions which are made by long- term associations and they give significance to the environment by defining and representing it. These associations are formed over repeated exposure (Aminoff, Kveraga & Bar, 2013).

Context can be formed by spatial or nonspatial associations. The first one refers to places and locations of certain objects. Furthermore, the nonspatial associations do not depend on location or spatial details but it specifies associations between items. Additionally, contexts can be divided into five types: Spatial context which refers places, configurations objects and characteristics of places. The temporal context means the time in which thoughts and events occur. The third one is interoceptive context that allude to hormonal and physiological states related with contexts. The cognitive context associates the context with the encoding and retrieving information (contextual processing). The last one is social and cultural context that means our experiences are defined by social settings and cultural contexts (Aminoff, Kveraga & Bar, 2013).

The encoding of contexts is done by a type of memory called contextual memory. This memory can evoke awareness episodes with relational information, but it also can learn context associations without access to awareness (Chun & Phelps, 1999).

Associative fear learning

Studies have proved the strong influence of the context on fear learning, even if this fear is trained to be extincted. In an experiment (Maren, Phan, & Liberzon, 2013), rodents were conditioned and then the stimulus was extinct to prove the relevance of the context in fear learning. First, some rodents were conditioned inside a specific box context, in which the animal encoded the context, after a bell noise is presented, and finally, it came a footshock. Through this conditioning, the rodent learned that this type of context is connected with a fear stimulus (footshock) because from that moment it always responded getting paralyzed. Next, it came the extinction of this conditioning respond (freezing). For this, the same rodent was put into a new arena in which the conditional stimulus (bell noise) was presented lot of times until the animal learned that there was not going to be a footshock (Maren, Phan, & Liberzon, 2013). Finally, a retrieval test was carried out to prove if the rodent, when is put inside in a new context, even if this fear was already extincted in another one, would reappear in this third new context. Results showed that when the bell noise is presented the conditional response (freezing) appeared. This research indicates that there is a contextual retrieval of fear memories after extinction. Importantly, recent studies indicate that the hippocampus is involved in regulating the context-dependence of extinction memories. Pharmacological inactivation of the hippocampus have revealed that the hippocampus plays an important role in contextual retrieval of fear memories after extinction. In addition, there is evidence that is necessary to retrieve the whole context, to emit the response of fear (Frohardt, Guarraci, & Bouton, 2000). In PTSD patients, they have deficits in the extinction of fear memory due to inability to form contextual memories (binding elements). PTSD patients encode elements separately, not as a part of a whole context. Therefore, the exposition to single stimulus leads to the re-experiencing the traumatic event.

Methodology

Participants

26 subjects (22 males and 4 females; mean age = 44.6, s.d. = 12.23, range 29-67 years) participated in this study and received monetary compensation for the transportation. Half of the group were diagnosed by a psychiatrist with PTSD and the other half were healthy subjects with no history of neurological or psychiatric diseases. Subjects with PTSD were recruited from a Psychiatric clinic ISNOR (Instituto del Sistema Nervioso del Oriente). Control subjects were selected by taking into account similar characteristics as age, sex and education level. The written informed consent from all persons was obtained before participation.

Stimuli and design

The main test selected was the completed version of the contextual cueing task (Chung and Jiang, 1998). It lasted 30 minutes and the results were processed in Matlab. The task consisted on finding a “T” stimulus between several “L” distractor stimulus. The “T” could be rotated 90 degrees to the right or to the left. Equally, the “L” stimuli had random orientation (0º, 90º, 180º, 270º). In each display there were 12 stimulus presented in random positions.
All displays included the “T” target and 11 “L” distractors located in an invisible 8x6 Matrix (37.2ºx 28.3º). The task contained 20 blocks, each one made of 24 trials (480 total trials). Each block consisted of 12 repeated and 12 new displays. In the repeated displays the location of all the stimulus were keepted as invariant, while in the new displays, new configuration of distractors were created in each block. Subjects pressed one of the two bottoms (“C” or “M”) at observing if the “T” was pointing the right or left side. Each trial consisted of the presentation of a fixation cross during 500 ms, a display presentation (for a maximum of 3 sec) and a variable

duration intertrial-interval (ITI; range 500–1000 ms). Also, between blocks there were ten seconds as a resting period. After completing all blocks, an explicit recognition test was performed to identify if subjects could recognise the repeated and new displays. They had to indicate if each display presented was repeated or new by selecting one of two keys. Subjects were seated 40 cm in front of the computer monitor (in a 17-inch Viewsonic VG710b LCD monitor), which had a gray background.

Next, they presented the Posner Spatial Cueing Task, which is a test that measured attentional processes. This test consisted in 200 trials and the objective was to press "A" key each time the target (X) showed up. At the beginning of each trial appeared a cross with arrows indicating in a 75% the probability of the target (X) arising in the right or left side (< +) (+ >). There was also another condition in which the cross could be presented with both arrows, so the target (X) could be placed in any side (< + >). The participants had to fix their eyes in the cross and pressed the "A" key whenever they saw the X stimulus.

Procedure

After obtaining the written informed consent. They performed the Contextual Cueing Task. Finally, they completed the Posner Spatial cueing task. Instructions and doubts were solved before starting each test.

Statistical analysis

This investigation used an experimental design. The independent variables were (1) Displays (new vs. repeated), (2) Epoch (1 vs. 4) and (3) Posttraumatic stress disorder (yes vs. no). By the other hand, the dependent variables were the reactions times and the contextual cueing effect. For analysis purposes SPSS was used. Search reaction times (RTs) of the 20 blocks were grouped into sets of five yielding four epochs and analyzed using three-way mixed ANOVA, based on trials performed correctly within [0.5, 3] sec. The contextual cueing effect was calculated as the difference in RTs between old and new displays collapsed across epochs 3–4 (Chun and Phelps, 1999). Differences in the magnitude of contextual cueing effect were evaluated with Student's t-test test.

Results

Contextual Cueing Task

Reaction times were analyzed using 2 (new vs. old display) x 2 (epoch 1 vs. epoch 4) x 2 (PTSD vs. control) ANOVA. There is a significant main effect of epochs (epoch 1 vs epoch 4), F (1,25)= 6,219, P= 0,02, indicating that during the task (as the epochs went by), search reaction times decreased.

By the other hand, the variables displays and PTSD did not indicate a main effect in the reaction times, displays (new vs. repeated), F (1,25)= 3,291, P= 0,08 and PTSD condition (PTSD vs. control), F (1,25) = 1,829, P= 0,18. Similarly, the interaction between epochs and PTSD was not significant, F (1,25)= 0,015, P= 0,90. Displays*PTSD, F (1,25)= 0,581, P= 0,45; and displays*epochs, F (1,25) = 0,001, P=0,98.

In addition, the statistics exhibited that there was not a relevant interaction between PTSD, displays and epochs, F (1,25)= 1,505, P= 0,232 .

Contextual cueing effect

The difference between PTSD and control reaction times were significant, (P=0.04, Student´s test), which suggest that control participants had better implicit contextual memory for repeated contexts.

Posner Spatial Cueing Task

Results did not demonstrate relevant significance between PTSD and control subjects in attentional focusing (P=0.131, Student´s test), which means that both groups are able to present similar levels of endogenous attention. Moreover, there was not a statistically significant effect in the involuntary attention (P= 0,354, Student´s test), meaning that the exogenous attention did not vary in subjects that present PTSD and healthy ones.

Discussion

The purpose of this research was to investigate if contextual information was affected negatively in patients with PTSD. Our results confirm that PTSD patients cannot encode all the elements of a context, which validate the Brewin's and Rudy model. The previous statement was demonstrated in our research comparing the development of PTSD and control subjects in the Contextual Cueing Task, finding that PTSD subjects exhibited difficulties in learning contextual representations, due to a deficit of the contextual implicit memory. These data are consistent with the structural MRI and functional MRI studies that revealed that there is a hypo activation and reduced volume of the hippocampus in PTSD patients.

As it is known, several studies have found that there is a reduction of the hippocampal volume in PTSD subjects compared with healthy controls. In addition, researchers have determined that, if there is an abnormality in the hippocampus, it will be also a dysfunction in the implicit memory. All this theory, joined with our results, support that PTSD patients have hippocampus abnormalities, and hence, contextual implicit memory difficulties. The previous statement may be associated with Shin (2009) and Kitayama's neuroimaging (2006), which states that people with PTSD have less gray matter (Kitayama et al., 2006) and metabolic abnormality in the hippocampus (Shin et al., 2009). Furthermore, Wang et al. (2010) discovered that a healthy hippocampus has specialized subfields for encoding implicit memory, meaning that if PTSD patients have irregular hippocampus, these areas will not work correctly. As a consequence, their performance in contextual memory tasks will be inadequate, as it is demonstrated in the present investigation.

Rudy (2009) and Brewin (2010) proposed models that explained context representations in PTSD patients, mentioning that when a healthy person lives a traumatic event it encodes all the elements of the scene, so for the appearance of the fear reaction, is needed the whole context of the trauma. By the other hand, because of the hippocampus damage, and therefore the difficulty to memorize contexts, a PTSD person cannot form a conjunctive representation of the event, so with the presence of just one element, the fear reaction is activated. The previous background is related with our results because, as the Rudy and Brewin's models, PTSD patients in the Contextual Cueing Task were not able to memorize the whole displays, even when they were presented several times. This fact evidenced that the contextual implicit memory is impaired in comparison to healthy controls.

Thus, it is possible to understand the obstacles that PTSD subjects present related with associative fear learning. Even if most of the studies have been done in rodents, it exists several similarities with PTSD patients. Our results show that they have difficulties to create a whole image of a context, which related with the traumatic event, means that they react with fear just with a unique stimulus of that event. It happens the same in rodents because of, though the stimulus was already extinct, they still freezing just with the bell noise, and not taking into account that the context is different from the one they were conditioned (Frohardt, Guarraci, & Bouton, 2000). Both researchers affirm that the associative fear learning is associated with the inability to create whole contextual representations.

As recommendations for future research, it is suggested the application of the instrument with a bigger sample of PTSD patients and also, to include the use of MRI that will permit to know if they have hippocampal volume reduction.

Conclusion

Previous investigations have confirmed a deeply relationship between the hippocampus and the contextual implicit memory and also, that this structure is implicated negatively in PTSD disorder. However, evidence was needed to find a connection between a deficit in implicit contextual memory and PTSD patients. Through the Contextual Cueing Task, this study has allow us to determine that PTSD patients have deficits in implicit contextual learning because they cannot differentiate between new and old displays. Although this research was performed with a limited sample, the results open a range of possibilities to continue investigating with more subjects and adding neuroimaging to prove that there is a hippocampal deficit while a contextual implicit memory task is accomplished.

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Appendices

Table 1
Sociodemographic data

PARTICIPANTS	AGE	GENDER	SCHOLARITY	PARTICIPANTS	AGE	GENDER	SHCOLARITY
PTSD 1	48	M	Technician	CONTROL 1	40	F	High school
PTSD 2	52	F	High school	CONTROL 2	38	M	High school
PTSD3	48	F	Postgraduate	CONTROL 3	29	M	Technician
PSTD 4	30	M	High school	CONTROL 4	41	M	High school
PSTD 5	39	M	Technologist	CONTROL 5	54	M	Postgraduate
PSTD 6	35	M	High school	CONTROL 6	62	M	High school
PSTD 7	58	M	Uncompleted high school	CONTROL 7	47	M	Postgraduate
PSTD 8	67	M	High school	CONTROL 9	30	M	High school
PSTD 9	35	M	High school	CONTROL 11	38	M	Technician
PSTD 12	33	M	High school	CONTROL 12	56	M	High school
PSTD 13	66	M	Uncompleted elementary school	CONTROL 13	45	M	Technician
PSTD 14	32	M	Technician	CONTROL 14	68	M	Uncompleted elementary school
PSTD 15	52	M	Postgraduate	CONTROL 15	35	F	Technologist
MEAN	45,769230769231				MEAN	45	
RANGE	30 - 67				RANGE	29-68	

TOTAL MEAN	45.5
TOTAL RANGE	29 - 68

Table 2

Three-way mixed ANOVA

Origen		Tipo III de suma de cuadrados	gl	Media cuadrática	F	Sig.
EPOCH	Esfericidad asumida	4,133	1	4,133	6,219	,020
	Greenhouse-Geisser	4,133	1,000	4,133	6,219	,020
	Huynh-Feldt	4,133	1,000	4,133	6,219	,020
	Límite inferior	4,133	1,000	4,133	6,219	,020
EPOCH * PARTICIPANTS	Esfericidad asumida	,010	1	,010	,015	,904
	Greenhouse-Geisser	,010	1,000	,010	,015	,904
	Huynh-Feldt	,010	1,000	,010	,015	,904
	Límite inferior	,010	1,000	,010	,015	,904
Error(EPOCH)	Esfericidad asumida	15,952	24	,665		
	Greenhouse-Geisser	15,952	24,000	,665		
	Huynh-Feldt	15,952	24,000	,665		
	Límite inferior	15,952	24,000	,665		
DISPLAYS	Esfericidad asumida	,035	1	,035	3,291	,082
	Greenhouse-Geisser	,035	1,000	,035	3,291	,082
	Huynh-Feldt	,035	1,000	,035	3,291	,082
	Límite inferior	,035	1,000	,035	3,291	,082

Table 3

Three-way mixed ANOVA

DISPLAYS * PARTICIPANTS	Esfericidad asumida	,006	1	,006	,581	,453
	Greenhouse-Geisser	,006	1,000	,006	,581	,453
	Huynh-Feldt	,006	1,000	,006	,581	,453
	Límite inferior	,006	1,000	,006	,581	,453
Error(DISPLAYS)	Esfericidad asumida	,253	24	,011		
	Greenhouse-Geisser	,253	24,000	,011		
	Huynh-Feldt	,253	24,000	,011		
	Límite inferior	,253	24,000	,011		
EPOCH * DISPLAYS	Esfericidad asumida	7,189E-06	1	7,189E-06	,001	,982
	Greenhouse-Geisser	7,189E-06	1,000	7,189E-06	,001	,982
	Huynh-Feldt	7,189E-06	1,000	7,189E-06	,001	,982
	Límite inferior	7,189E-06	1,000	7,189E-06	,001	,982
EPOCH * DISPLAYS * PARTICIPANTS	Esfericidad asumida	,020	1	,020	1,505	,232
	Greenhouse-Geisser	,020	1,000	,020	1,505	,232
	Huynh-Feldt	,020	1,000	,020	1,505	,232
	Límite inferior	,020	1,000	,020	1,505	,232
Error(EPOCH*DISPLAYS)	Esfericidad asumida	,327	24	,014		
	Greenhouse-Geisser	,327	24,000	,014		
	Huynh-Feldt	,327	24,000	,014		
	Límite inferior	,327	24,000	,014		

Alpha = ,05

Table 4

Three-way mixed ANOVA

Origen	Tipo III de suma de cuadrados	gl	Media cuadrática	F	Sig.
Intersección	304,805	1	304,805	101,457	,000
PTSD	5,494	1	5,494	1,829	,189
Error	72,103	24	3,004		

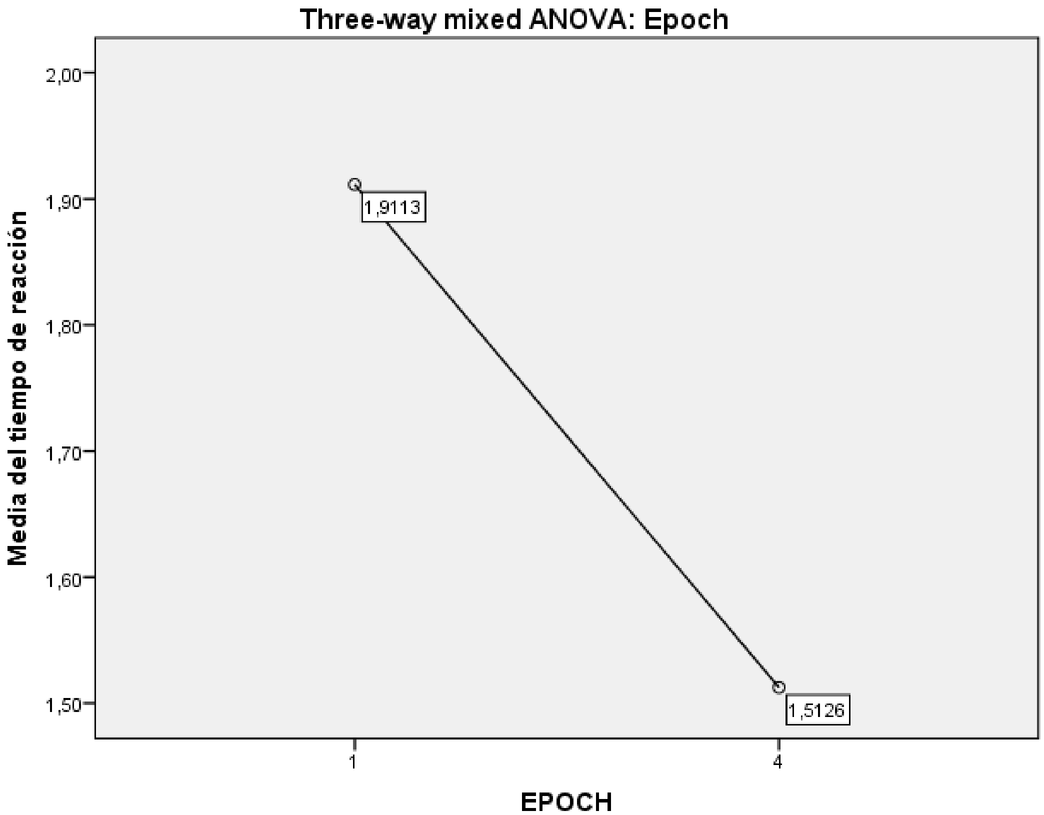

Figure 1
Three-way mixed ANOVA

Table 5
Student's T-Test Contextual Cueing Effect

STUDENT'S T-TEST CONTEXTUAL CUEING EFFECT						
		F	Sig.	t	gl	Sig. (bilateral)
CCE	Equally variances	,309	,583	-2,168	24	,040
	Not equally variances			-2,168	21,833	,041

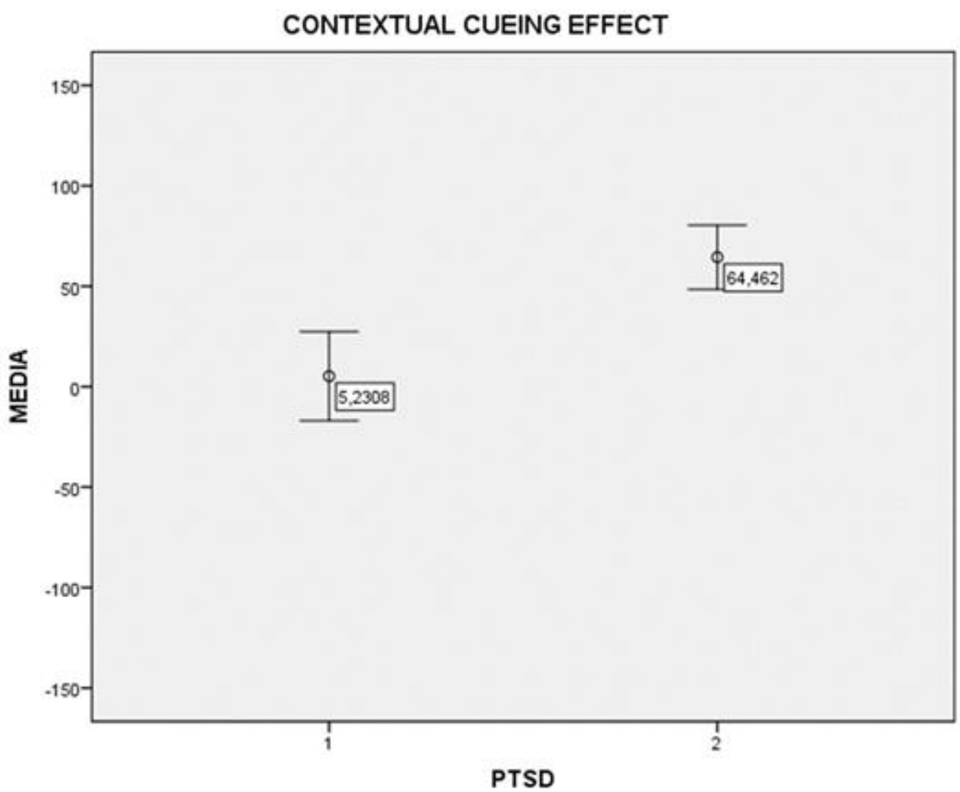

Figure 2
Contextual Cueing Effect

Table 6
Student's T-Test Attentional focusing

		F	Sig.	t	gl	Sig. (bilateral)
ATTENTIONAL FOCUSING	Equal variances	,000	,994	1,570	24	,129
	Not equal variances			1,570	21,299	,131

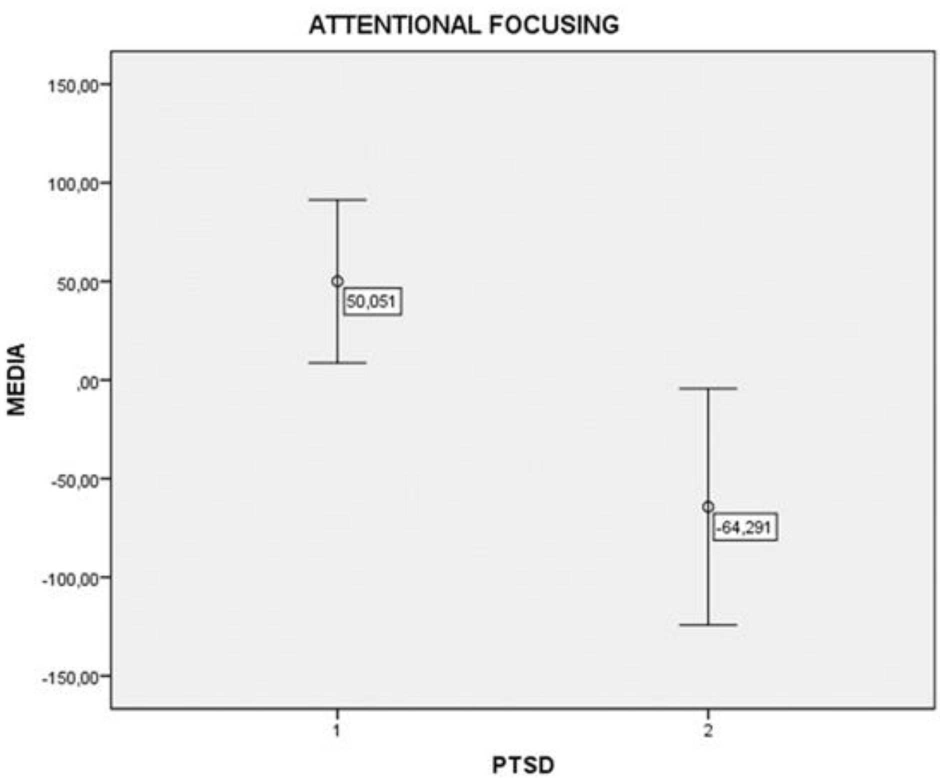

Figure 3
Student T-Test Attentional Focusing

Table 7
Student T-Test Involuntary Attention

		F	Sig.	t	gl	Sig. (bilateral)
INVOLUNTARY ATTENTION	Equal variances	2,076	,163	-,952	24	,351
	Not equal variances			-,952	18,108	,354

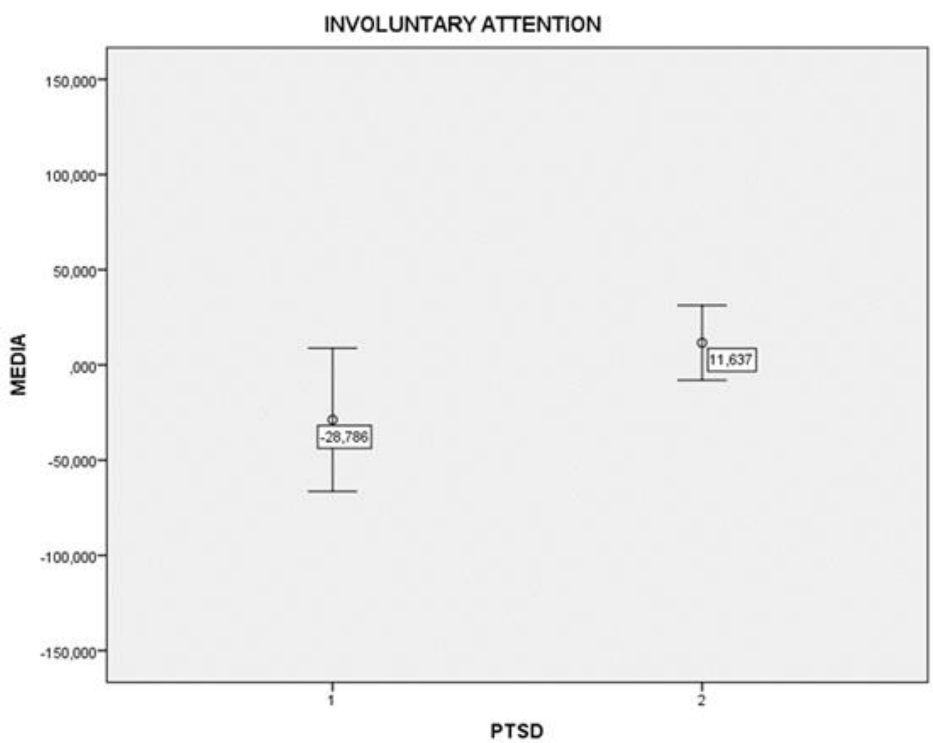

Figure 4
Student T-Test Involuntary Attention