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Memory for emotional material in temporal lobe epilepsy

Claudia P. Múnera [a,b,*], Carolina Lomlomdjian [a,b], Verónica Terpiluk [a,b], Nancy Medel [a,b], Patricia Solís [a,b,c], Silvia Kochen [a,b,c]

[a] Epilepsy Center, Neurology Division, Ramos Mejia Hospital, Gral Urquiza 609, C1221ADC CABA, Argentina
[b] Center for Clinical and Experimental Neurosciences: Epilepsy, Cognition and Behavior, Cell Biology and Neuroscience Institute (IBCN), School of Medicine, UBA-CONICET, Paraguay 2155, 2nd Floor, C1121ABG CABA, Argentina
[c] National Neuroscience and Neurosurgery Center, El Cruce Hospital, Av. Calchaqui, 5401, C1888 Florencio Varela, Buenos Aires, Argentina

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ABSTRACT

Several studies suggest that highly emotional information could facilitate long-term memory encoding and consolidation processes via an amygdala-hippocampal network. Our aim was to assess emotional perception and episodic memory for emotionally arousing material in patients with temporal lobe epilepsy (TLE) who are candidates for surgical treatment. We did this by using an audiovisual paradigm. Forty-six patients with medically resistant TLE (26 with left TLE and 20 with right TLE) and 19 healthy controls were assessed with a standard narrative test of emotional memory. The experimental task consisted of sequential picture slides with an accompanying narrative depicting a story that has an emotional central section. Subjects were asked to rate their emotional arousal reaction to each stimulus after the story was shown, while emotional memory (EM) was assessed a week later with a multiple choice questionnaire and a visual recognition task. Our results showed that ratings for emotional stimuli for the patients with TLE were significantly higher than for neutral stimuli ($p = 0.000$). It was also observed that patients with TLE recalled significantly less information from each slide compared with controls, with a trend to lower scores on the questionnaire task for the group with LTLE, as well as poorer performance on the visual recognition task for the group with RLTE. Emotional memory was preserved in patients with RTLE despite having generally poorer memory performance compared with controls, while it was found to be impaired in patients with LTLE.

1. Introduction

Why do we remember the events that occurred on September 11th 2001 but not what happened the day before? Why can we describe vivid details about our wedding day but barely remember a workday last year? Past studies have found that emotionally arousing events are more often retrieved than neutral or nonsignificant events [1]. Once retrieved, emotionally arousing events are frequently recalled with high accuracy and vividness [2] and sometimes involve trivial aspects like incidental sights or sounds [3].

Emotion is known to modulate declarative forms of memory [4] by improving the initial encoding of a memory trace [5] and its consolidation [6]. Prior research has shown that the hippocampal-amygdalar network fulfills an important role during these processes [7]. The modulation hypothesis states that the amygdala mediates the encoding and storage of emotionally arousing material, while the hippocampus is involved in the retrieval of the emotion-related declarative memory (EM) [8,9] and in the formation of "episodic representations of the emotional significance and interpretation of events" [7,10,11].

Both the amygdala and the hippocampus are activated during emotional events and interact actively to form long-term memories of these events [12]. Most of the research in EM has been carried out in subjects with amygdala damage [8,13,14], showing that the memory enhancement benefit is lost in patients with bilateral amygdala lesions and diminished in those with unilateral damage [15]. Patients with medial temporal lobe epilepsy (MTLE) provide a unique opportunity to systematically explore different memory processing aspects of emotional content. These patients allow us to consider the hippocampus-amygdalar involvement that could be mediated by seizure onset or by the connectivity of neural networks related to the spreading of the seizure, as well as variable changes in other cortical areas.

Previous research on emotional memory in patients with TLE yielded controversial results depending on the type of task used and if they were focused on presurgical and postsurgical patients. Thus, memory enhancement for highly emotional stimuli has been reported as reduced despite normal perception of emotional stimuli [16,17] or showing similar benefits (implying advantages or enhanced likelihood of remembering it later) as controls [18]. Most prior studies with

Abbreviations: EM, emotional memory; TLE, temporal lobe epilepsy; LTLE, left temporal lobe epilepsy; RTLE, right temporal lobe epilepsy; EZ, epileptogenic zone.

* Corresponding author at: Epilepsy Centre, Neurology Div, Ramos Mejia Hospital, Gral Urquiza 609, CP1221 Buenos Aires, Argentina.
E-mail address: claudia.muneramartinez@gmail.com (C.P. Múnera).

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postsurgical patients, and a few conducted in nonresected patients with TLE, have suggested that emotional memory enhancement varies depending on the association with an amygdalar lesion [19].

The present study aimed to explore the involvement of the hippocampal–amygdalar complex in emotional perception and EM in patients with TLE cleared for surgical treatment using an audiovisual story paradigm. We administered a test that has previously been used on different clinical populations [3,8,10,13,15,20] including postsurgical patients with TLE [18] but not presurgical patients with TLE.

2. Material and methods

2.1. Participants

Forty-six patients with pharmacoresistant temporal lobe epilepsy (TLE) and who were candidates for surgical treatment (between 18 and 53 years) were examined at the Epilepsy Center of the Ramos Mejia Hospital in Buenos Aires and at the National Neuroscience and Neurosurgery Center, El Cruce “Dr. Nestor Carlos Kirchner” Hospital in Florencio Varela (Argentina). Patients were matched for age, education, and sex with 19 healthy control subjects. Only patients with a full-scale IQ of >70 (WASI) and without history of psychiatric disorders or other neurological diseases were included (Table 1).

All subjects gave written informed consent approved by the Institutional Ethics Committee at Ramos Mejia Hospital, which follows the guidelines of the Declaration of Helsinki.

In order to determine lateralization and localization of the epileptogenic zone (EZ), video-EEG monitoring and magnetic resonance imaging (MRI) testing were performed for each patient. A neuropsychological assessment was performed according to the EC presurgical protocol using the z-score value of −2 as the cutoff [21,22].

2.2. Experimental tasks

To assess EM, we used two similar tasks, the Heuer and Reisberg test [3] (Task A) and its modified version developed by Cahill and others [8,10,13,20] (Task B). The first stage of our procedure, which was carried out 4 to 12 months prior to surgery, consisted of baseline testing sessions where both tasks (A and B) were randomly administered among participants. The second stage was carried out only in those patients who underwent surgery and is not reported here because of ongoing testing. To avoid content-learning effects between stages, participants were tested with different tasks at baseline (e.g., Task A) and when they were operated on (e.g., Task B).

The first story (Task A) contained a set of 11 pictures about a boy who suffers a terrible car accident on his way to visit his father at work and how he has to be rushed to the operating room at the hospital. The second story (Task B) included a total of 12 photos depicting a story about a son visiting his father at his workplace, who turns out to be a surgeon assisting a victim of an accident, and the child seeing him performing the surgery. Both verbatim narratives (A and B) were translated to Spanish from a previous published version [8]. Some original pictures were replaced to make them more relevant to Argentinean culture but maintaining the same structure and grouping emotionally arousing stimuli as the original ones. The stimuli adapted were as follows: woman with child, bus stop, hospital entrance, and police station. Both tasks comprised a series of sequential picture slides and an accompanying narrative depicting a story. Each story included an emotional central segment (phase 2: slides 5–8) preceded by a section that set the scene (phase 1: slides 1–4) and followed by the repercussions of the main event (phase 3: slides 9–12). The first and third sections were neutral or nonemotional.

The slides were projected on a computer screen using E-prime version 1.0 and were shown along with the previously recorded narrative. Participants were told to pay attention to the story to rate the emotional reaction after the presentation. Memory tests were incidental since participants were unaware that they had to retrieve any kind of information.

After the slides were shown, we carried out a set of tasks [8,13]:

1 Emotional personal reaction: immediately after the presentation, each stimulus was shown once again, and participants were asked to rate their emotional arousal reaction to each of the slides on a scale from 1 to 10 (1 = none, 10 = high impact).
2 Questionnaire: EM was assessed a week after the story was shown using a multiple choice questionnaire [3,8] translated to Spanish, which asked ten questions per slide. Each question was displayed on a computer screen using E-prime version 1.0 and included four possible answers, which resulted in a chance response level of 25%. Subjects had to press the number of the response they considered correct using a keyboard in order to continue to the next question. The questionnaire was conducted a week later because the results are going to be compared with a postsurgical assessment, when the critical recovery period is over.
3 Visual recognition memory: after the questionnaire, subjects were shown the original pictures and 20 lures (e.g., pictures that showed a similar situation but in a different place) on a computer screen using E-prime version 1.0. Subjects had to indicate whether or not they had previously seen the image, using a keyboard. Response latencies to each picture were automatically recorded. Thirty-two subjects with TLE (19 with left TLE and 13 with right TLE) and eighteen control subjects participated in this task.

2.3. Statistical analysis

The group with TLE and the control group were matched for age, sex, and formal education. For each patient, the raw values of every cognitive test in the neuropsychological battery were normalized to a z-score and classified as a ‘deficit’ for values less than or equal to −2.

We compared performance on the personal emotional reaction and emotional memory tasks of the group with LTLE and the group with RTLE with that of the control group using Student's *t*-test, one-way ANOVA analysis, Bonferroni correction post hoc test, nonparametric test (Wilcoxon), and Pearson correlation coefficient r. The slight difference between Task A and Task B was adjusted to run the analysis.

All comparisons that were significant at the $p < 0.05$ level were reported. Statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS version 20).

3. Results

3.1. Emotional personal reaction

A paired samples *t*-test indicated that, as expected, subjects with TLE and control subjects endorsed significantly higher subjective ratings in highly emotional compared with neutral stimuli: for phase 2 versus phase 1: TLE − $t(44) = -10.72$, $p = 0.000$; controls − $t(18) = -8.98$, $p = 0.000$ and for phase 2 versus phase 3: TLE − $t(44) = 7.96$, $p = 0.000$; controls − $t(18) = 6.68$ $p = 0.000$. We observed that patients with TLE tended to assign higher scores compared with controls in each phase, with a statistically significant difference in phase 1 ($t(57.91) = 2.43$; $p = 0.018$) and phase 2 ($t(62) = 2.57$; $p = 0.013$) (Fig. 1). There was no effect of EZ side in any phase. When subjects' ratings for each picture were analyzed, results did not show relevant differences between subjects with TLE and control subjects, with no effect of EZ side.

3.2. Questionnaire of emotional memory

Patients with TLE retrieved significantly less information for each stimulus (highly emotional and neutral) compared with the control group ($p < 0.05$; Student's *t*-test). The group with LTLE obtained lower