Emotional arousal enhances declarative memory in patients with Alzheimer’s disease


Objective – To verify whether the long-term retention of an emotionally arousing story is stronger than the retention of a neutral story, and the enhancing effects of emotional arousal on declarative memory in Alzheimer’s disease (AD) patients. Method – Twenty subjects (10 with AD and 10 controls matched for age and educational level) were studied. After the audiovisual presentation (neutral story), the subjects rated the narrative’s emotionality. Later, they answered a multiple-choice questionnaire about the stories. Two weeks later, they watched the emotionally arousing story. Results – Subjects who watched the emotionally arousing story assigned a score of emotionality higher than the subjects in the neutral group ($P = 0.023$). In addition, the participants remembered more details of the arousing story, and had a higher score in the questionnaire ($P < 0.001$). Conclusions – We demonstrated that an emotionally arousing content enhances long-term declarative memory in AD. Furthermore, present finding supports the use of this instrument for clinical and research purposes.

Introduction

It is well known that memories of happy and sad moments seem more resistant to the decay of time than other less striking events. Experimental studies have demonstrated that emotional arousal enhances declarative memory in healthy individuals (1–5), amnesic patients (3, 6), and patients with AD (7–11). These findings suggest that emotional arousal produced by certain situations strengthens the consolidation of new information (12).

Studies on emotion have shown that particular characteristics of pictures may elicit an emotional response that varies according to the valence (positive to negative) and to the arousing property of the stimuli (from neutral to exciting) (13). According to this, Ikeda et al. (11) affirm that fear reinforces memory retention in AD.

Emotional memory has the same characteristics of declarative memory. It is an episodic memory of emotional events. Under special circumstances, these memories are also referred to as ‘flashbulb’ memories (14).

Studies with animal models involving declarative emotional memory suggest that the amygdaloid complex (AC) plays a critical role in modulating the formation of long-term memory associated with emotionally arousing events (15,16). Findings from extensive research involving both human and animal subjects substantiate the notion that modulation of memory storage for emotionally arousing events occurs, at least in part, by interaction of endogenous stress memory systems (especially catecholamines) and the AC (in particular the basolateral amygdala) (17). The degree of arousal produced by unconditional stimulus and not the aversive nature per se, determines the level of amygdala involvement in a learning situation. In this way, the amygdala should be important for long-term memory formation whenever the learning conditions are sufficiently emotionally arousing to engage the amygdala, independent of whether the particular emotions involved are positive or negative (18).
Different instruments and stimuli have been used in emotional memory studies, such as memories of real-life episodes, word lists, facial expressions, neutral and emotional pictures, short movies with arousing content, and narrated or visual stories.

In AD, the hallmark feature is the dramatic memory deficit that occurs early in the disease process. This deficit is presumed to result from neuropathological changes in the medial temporal lobe, regions that are critical for declarative memory (19). From this result, we know whether patients show a normal enhancement of emotional memory. Several results have been found with AD samples. So far, very few investigations have demonstrated a marked impairment in memory enhancement effect for negative pictures. Abrisqueta-Gomez et al. (20) studied recognition of positive, negative and neutral pictures (pleasant, unpleasant or indifferent). They confirmed that emotional content enhanced recognition of pictures in normal subjects, who benefited from the affective content, while in patients with AD, the emotional significance attached to the pictures did not facilitate their recognition. Similar results with AD patients have been reported in studies with positives pictures, negative and positive words, and negative sentences (21). In contrast, other researchers have demonstrated a relatively intact enhancement effect for positive pictures (22), negative stories or film clips (8, 23, 24), and real-life events (10, 11) in investigations with AD patients.

Ikeda et al. (11) examined patients with AD who experienced an earthquake in Kobe, Japan, 2 months after the disaster. They verified that memories related to the earthquake were relatively well retained in comparison with an event that had less emotional involvement, suggesting that extraordinary emotional involvement in the experience enhanced learning and long-term memory.

In a study with word lists (7), all subjects were given three trials of a three word list. The words were positive, negative, or neutral in valence and matched for concreteness, emotionality and pleasantness. The results showed that the control’s performance was better than the AD patients. However, the control group recalled all emotional words regardless of their valence, while AD patients recalled significantly more negative words than positive or neutral. This suggests that emotional valence is an important variable in studies with emotional memory involving Alzheimer’s disease.

Thus, the enhancement effect in AD patients depends on a series of within-group factors: sex, age, disease severity; and between-group factors: valence (positive or negative), arousal (calming or exciting), encoding instructions (easy or difficult), viewing time, semantic coherency, arousal level, and the complexity of the target events (visual or/and auditory).

On the basis of bibliography, it is possible to see that prior studies that found blunted emotional memory enhancement in AD used sets of briefly presented stimuli that lacked semantic coherence. In contrast, the majority of studies that found an enhancement effect in AD used stimuli with semantic coherence that were processed for longer periods of time. Significant differences had been found when stimuli with a major complexity and higher arousal level (a real-life event or a narrated slide show) were employed. Therefore, these characteristics could affect whether or not AD patients demonstrate an enhancement effect.

The recall of narratives has been employed in a number of memory assessments (1, 2, 6, 25–27) and is considered a useful measure to assess recall and recognition (27). Consequently, the aim of this study was to determine whether long-term retention of an emotionally arousing story is stronger than retention of a neutral story and is bigger than the enhancing effects of emotional arousal on declarative memory in patients with AD than the control.

This study follows the line of research that examines the retention of information of an emotional experience of relatively no traumatic intensity, and involves visual and verbal modality. We administered the same methodological criteria used by Kazui et al. (8).

Materials and methods

Subjects

All patients and controls were voluntary research subjects from the University Hospital of Brasilia (HuB), Brasilia, and gave informed consent prior to participation, according to the ethical guidelines for research with humans (196/96 CNS/MS resolution).

Ten patients (five women and five men) with probable AD were evaluated. Ten healthy subjects (seven women and three men) matched for age, gender and educational level were used as the control group. The patients with AD had a history of cognitive decline and memory problems, but showed normal consciousness.

All participants were examined by neurologists and psychologist and were given standard neuropsychological examinations. The inclusion criteria were those of the National Institute of Neurological and Communicative Disorders and
Stroke/Alzheimer’s Disease, and Related Disorders Association for probable AD (28), the Clinical dementia rating (29) and the Mini-Mental State Examination adapted to Portuguese (30). Patients with other specific causes of dementia, brain lesions, delirium, and depression were excluded.

Material

We employed slide presentations of two short stories accompanied by a narrative. These stories had been previously adapted to a Brazilian sample (2) and kept as close as possible to the original ones.

The stories tell about a mother and son going to visit the father’s workplace. The slides are the same, but there is a difference in the story content. In the neutral version, on their way to visit the father, they pass by a car accident that calls the child’s attention. In the hospital, where the father works, the child participates in an emergency drill. In the arousal version, the child suffers a bad car accident on his way to visit his father and is critically hurt. He is operated on at the emergency room. The story’s content can be divided into three phases, with the second phase (slide 5–8) being the emotionally strongest phase of the story.

The subjects were asked to answer an 11-item questionnaire about the stories. We did not use Kazui’s standard administration methods (8) due to the patients’ memory impairment. Instead, we selected items for the Portuguese version (2) from a simplified recall test. One of the main differences compared to the questionnaire used by Kazui et al. (8) was that we asked two or three questions for each slide obtaining the same number of answers (eight) for each phase. Furthermore, we gave 1 point for a correct answer and 0 point for an incorrect one.

Procedure

Images were presented to the participants on a 17 in. high-resolution color monitor at a rate of 20 s per slide. The subjects were told to pay attention to the pictures and the narrative, and to remember the story. Immediately after the presentation, they were asked to rate the emotional content of the whole story on a scale of 1 to 4, with 1 indicating ‘not emotional’ and 4 indicating ‘highly emotional’. Five minutes later, the subjects were given an 11-item recall test (reduced version). The photographs were presented one by one again in the same order; subjects were asked about the story line. The second part of the experiment was carried out after an interval of 2 weeks. On this occasion, the experiment was repeated with the same sets of images, but with an emotion filled narrative story instead of the neutral story narrative. We did not separate the groups into two subgroups due to the fact that all participants watched the neutral story in the first session and the arousal story in the second, to prevent influencing the participants’ recall. In this way, there was no emotional influence that could possibly interfere with their performance.

Data analysis

Results obtained did not fit the requirements for the parametric statistical analysis. Therefore, the receiver operating curve (ROC) was used to evaluate the sensitivity and specificity for a binary classifier system. Also, the fraction of true positives (TP) vs the fraction of true negatives (TN) was verified in the two versions: AD diagnosis or no Alzheimer (controls) according to previously established inclusion criterion. ROC test was applied to analyze each version and each variable to determine the best exclusion criterion for the scores applied for each variable (Table 1). Bonferroni’s test was used to make the comparisons between and within groups, respectively.

Results

As regards the total number of correct answers for the questionnaire, an ANOVA of two factors,
Version of the stories (Arousal and Neutral) and Group of participants (Controls and Alzheimer's subjects), showed a significant difference depending on the version of the stories attributed to the group of participants ($F(1,36) = 36.397$, $P < 0.001$). Subsequently, Bonferroni's post hoc test for multiple comparisons indicated that the participants with AD displayed lower values of correct answers in the three phases of the test than the controls (Fig. 1).

Taking these results together with the data from the ROC’s findings, it is possible to affirm that the control subjects obtained 22 points or more in the classification of correct answers while the AD scored less than 22 points.

According to the sensitivity (0.5) and specificity (0.6) levels, the arousing version did not distinguish the two groups. On the other hand, exposure to the neutral version yielded significant ranges of sensitivity (0.7) and specificity (0.8), indicating that this variable was strongly discriminatory.

Analysis of the scores assigned for emotional value in the factor group (participants) and the version of the test, yielded significant differences attributable to the 'Version' factor ($F(1,36) = 5.64$, $P = 0.023$), and significant interactions between factors ($F(1,36) = 4.24$, $P = 0.047$).

Within the Alzheimer group, there were no significant differences attributable to the version, but when considering the neutral version, the Alzheimer patients attributed a higher emotional rating than the controls, differing from the emotional version, which showed no significant differences for the groups (Fig. 2).

Bonferroni’s analysis ($P < 0.05$) indicated that as a whole, the arousing version had a stronger effect on the scores than on the scores given to the neutral version. Bonferroni’s analysis ($P < 0.05$) indicated that as a whole the arousing version had an expressive impact on the results.

In general, the total correct answers for phases 1 and 2 showed reasonable discriminative power, unlike the correct answers for phase 3, that displayed satisfactory sensitivity, but low specificity.

The differences between the two versions of the test (arousal and neutral) are centered in the contents of phase 2, leading to the conclusion of a significant difference attributable to diagnoses ($F(1,36) = 40.375$, $P < 0.001$), but no significant differences attributable to the version of the test (Fig. 3).

Bonferroni’s analysis showed that the participants with AD displayed lower numbers of correct answers than the controls. This suggests that the emotional alert produced no increment to the mnemonic performance in this group, but both versions of the test were sensitive to the Alzheimer diagnosis.

A general analysis of tests’ results displays that the variable total number of correct answers is the best discriminator of the positive or negative diagnose of Alzheimer type Dementia. This is
demonstrated in phase 2 of the questionnaire in the Neutral Version (ROC = 0.97), where the expected best exclusion value is 8 correct answers, followed by total correct answers in the Arousing Version (ROC = 0.96), with the best exclusion criterion of 22.

It is important to emphasize that as the control group was composed of healthy participants, the exclusion criterion was used as a normalization criterion for these experimental conditions. Confrontation of these results with ROC confirms that the variable total correct answers for the arousing version showed the best exclusion criterion in 22 correct answers.

Discussion

The findings indicate that a narrative with high emotional content can enhance conscious recall of information in humans, i.e. declarative memory.

The rating for the emotional content of the arousing story was significantly higher than that of the neutral one, just for the AD group. The performance of the control group was lower in the emotional version of the narrative than in the neutral one. These results strongly indicate that the enhancing effect of emotional arousal on declarative memory is preserved in patients with AD, also demonstrating that this emotional variable is more discriminative in AD.

When the neutral version was considered, the AD group attributed a higher emotional score than the control group. This perception of higher emotionality did not have any repercussion on the mnemonic performance in these patients. However, in the control group, a significant increment of the mnemonic performance was verified. This suggests that the emotional alert produced no significant increase in the mnemonic performance in the groups, but the emotional version of the test was sensitive to the Alzheimer diagnosis. In this way, the AD group recalled more details of the arousing story. Although Alzheimer patients had deficit in story recall, they displayed a better memory for emotionally negative events when compared with healthy controls (the emotional arousal used in the present study was negative in stories. A comparative analysis of the stories recall within the AD group showed a higher performance and recall in the arousing version.

The influence of emotion on memory is not a purely cognitive or affective phenomenon, but a property of an aroused physiological activation. There are biological mechanisms involved in this aspect of emotional memory (6). Therefore, presumed damage to AD patients' amygdala may explain the present results. Several authors (10, 22) have described amygdala's role in emotional behavior and cognition. Thus, we agree with Kazui et al. (8) that the impairment of the enhancing effects of emotional arousal on memory reflects the degree of damage to the amygdala.

A phase-by-phase comparison of the results showed that the arousing story was better recalled than the neutral story only in phase 2, in which the emotional impact of the arousing story was higher than that in the neutral story, just for the AD group. The performance of the control group was lower in the arousal than in the neutral story. These results strongly indicate that the enhancing effect of emotional arousal on declarative memory is preserved in patients with AD, also demonstrating that this emotional variable is more discriminative in AD.

Analyzing phase 2 in its entirety, it is important to point out that the AD group was able to recognize and label emotions associated with the narrative at a rate not significantly different from that of the matched controls, although AD patients judged the emotional version less emotive than the control subjects. Also, patients were able to identify the pictures and interpret their meaning as well as the controls. These arguments are in agreement with those from previous investigations (23), supporting the idea of preserved emotional processing in early AD.

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nature). This conclusion has some important implications for the management of dementia rehabilitation and treatment.

In conclusion, our data are in disagreement with those of Abrisqueta-Gomez et al. (20). The reason for this discrepancy could be because of the tool used to assess the benefit from the emotional content. Abrisqueta-Gomez et al. (20) investigated AD memory with emotionally charged pictures that did not have any relation to the subjects’ personal experiences in contrast with our work tool. However, we agree with these authors’ conclusion that AD patients do not benefit from the emotional content of stimuli even at mild to moderate stages of the disease.

The recall results in the present study suggest that this instrument is a valid tool to examine emotional memory in subjects with probable AD. It is also useful in comparing healthy subjects with dementia patients. A goal for future studies is to compare the variable recall performance in relation to the memory decline along the various stages of the disease.

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References