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Do Stress and Anxiety Impact Memory? An Exploratory Portuguese Study

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ABSTRACT

Eyewitness memory is widely studied in the forensic context, due to their proneness to make unreliable testimonies. Understanding which factors may impact memory is determinant to avoid wrongful convictions in court. In this exploratory study, the relation between stress and anxiety and memory errors (spontaneous and induced) was analyzed being hypothesized that negative emotions may impair memory performance. Crime and neutral videos were presented to 80 volunteer university students in a between subject-design. They were asked to fill some stress and anxiety scales throughout the experimental task, as well as a free recall task. Also, it was presented several questions about the videos in which spontaneous and induced errors were assessed. Results suggests that stress and anxiety did not influence the quantity of memory errors for both genders. However, overall memory performance was poor for both conditions. Our results were discussed in light to existing theories about the relation between stress-anxiety and memory.

1. Introduction

The relation between psychology and justice emerged in the nineteenth century after several cases of people who were wrongfully convicted for crimes they had not committed. Most of these unfair convictions were caused by eyewitnesses' identification mistakes and false testimonies although they believed they were telling the truth^[1, 2].

In the absence of physical or other incriminating evidence, witnesses are fundamental in court since their testi-

mony may be crucial for the judge's decision-making^[3, 4, 5, 6]. Nevertheless, memory itself is fallible because it can be contaminated, adapted or lost, leading to either an erroneous reconstruction of the events^[7] or the recalling of events that never happened, so called false memories^[8, 9].

False memories can be formed spontaneously or can be implanted. During the acquisition/coding process, one can acquire, storage and recalling the information in a biased way attending to social beliefs, experience and expectations of the individual^[10]. On the other hand, false memo-

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ries may be created by the suggestion of others^[11]. When someone experience a specific event, and subsequently provide misleading information about that same event, people end up making mistakes when reporting what they have seen or experienced^[9, 12]. This phenomenon, known as the *misinformation effect*, has been tested in several investigations and consists of presenting the original event, introducing new events that are not related to the original, followed by a memory test^[13, 14, 15].

Importantly, when a crime occurs, there are central and peripheral details that are memorized. Central details are considered extremely important from the legal point of view, since they refer to the physical characteristics of the perpetrator. However, peripheral features must also be considered as they may provide details that are relevant^[16]. The central details are associated with the anxiety-producing event (crime), in particular the physical characteristics of the perpetrators and the victims. The peripheral details, however, refer to what goes on around the event, that is, the details of the environment and the situation or action itself^[11]. When a witness is asked to remember the details of the event, it is usually best remembered the central details while the peripheral details are more prone to disinformation or distortion^[17].

Although false memories and memory errors are two related topics, we will focus in the last ones. Memory errors refer to incorrect recall for specific information of occurred events by internal and/or external factors^[18], such as stress and anxiety. Some authors suggest that stress and anxiety impair the memory of eyewitnesses, which leads to a less efficient performance^[19, 20] since increased anxiety is significantly correlated with increased error in the description of the event^[21].

Although it is found that an event with a high negative emotional load allows an improvement to central details than peripheral ones, individuals still commit many errors in the offender identification^[22]. Other investigations show opposite results, reporting an improvement in memory in stressful and emotionally arousing events^[23, 24] and that these variables improve the performance of witnesses for details^[23]. In these situations, an anxiety and stressful context may allow individuals to become more attentive to what is going on in their surrounding environment, assimilating more details^[25].

When a person witnesses a crime, s/he experiences more or less levels of stress^[26]. Stress can be defined as a negative emotional state, associated to physiological changes that are related to the increase of the arousal and consequent increase of the heart rate, blood pressure and contraction of the muscles, as to a subjective set of cognitions, that is, of thoughts^[26, 27].

Another relevant variable is anxiety, which can be classified by state-anxiety and trait-anxiety. Anxiety-state is characterized by a transient emotional state that includes unpleasant feelings of tension and conscious apprehension due to increased activity of the nervous system; on the other hand, trait-anxiety is related to the individual differences of each person, which are relatively stable^[28, 29]. Although anxiety arises frequently as a response to stress, these concepts are distinct. While anxiety is an adaptive response, overcoming certain thresholds becomes pathological^[28], stress arises as a response to a specific event^[26]. Roberts^[30] found that anxiety mainly affects the memory of individuals who have low trait-anxiety levels and who in crime contexts present high levels of anxiety. However, individuals who have high levels of trait-anxiety and trait-anxiety, are more developed with strategies to deal with anxiety. This raises the question that individuals with low levels of trait-anxiety, in emotional contexts that elicit high anxiety, are more likely to create more errors, contrary to others that do not have strategies to deal with anxiety.

Anxiety may be present, not only during the crime, where the subject encodes the information of the event, but also at the interview made by the police where the witnesses have to share the details that s/he remembers of the event^[19, 31]. It is also relevant to pay attention to the type of questions made in order to avoid the increment of the anxiety in the witness and the disruption of her/his memory.

Similarly, in crime contexts and concern to gender, Areh^[32] found that women are more reliable eyewitnesses when compared to men, since they are more accurate in the descriptions of the offender. Men are more confident in their responses to the details of the location, that is, where the crime occurred. Effectively, women seem to have better overall memory for crimes by performing significantly more accurately than men on recalling the event, as well as they are more effective in the description of perpetrators, even when the perpetrator is a woman^[33].

Despite the diversity of studies related to memory errors, there is still a lack of consensus regarding the effect of anxiety and stress in memory. In fact, some studies reported that these variables are beneficial in the recalling of the events, while others mention an opposite pattern. This study intends to verify if a situation that produces anxiety and stress influence the production of spontaneous and induced errors (hypothesis 1). Participants were divided by gender to evaluate the quantity and quality of memory errors, expecting woman to have a better performance compared to men (hypothesis 2).

2. Method

This experiment was approved by the Ethics Committee of the Lusófona University of Humanities and Technologies, Portugal. Moreover, the guidelines of the Declaration of Helsinki and the standards of the American Psychological Association were followed.

2.1 Participants

Eighty-two university students with accurate or corrected vision (42 men aged between 18 and 58 years, *Mean* (*M*) = 23.2, *Standard Deviation* (*SD*) = 6.2, and 40 females aged between 18 to 42 years, *M* = 22, *SD* = 4.3) from Lusófona University of Humanities and Technologies volunteered to participate. Two participants were excluded for not complete the questionnaires.

2.2 Instruments and Materials

The State-Trait Anxiety Inventory (STAI; Portuguese study) [34] was used to assess participant's anxiety. This is a self-response scale which consists of two subscales with twenty items each (STAI-Y1 to measure state-anxiety and STAI-Y2 to measure trait-anxiety). The responses are provided by choosing one of the four options (1-4 points); The total score of each subscale ranges 20 (minimal anxiety) to 80 points (maximal anxiety). The Portuguese validation study (age-range: 15-69 years old) revealed good psychometric properties, such as a good Cronbach alpha ($\geq .87$). This inventory is widely used and it allows to assess the two dimensions of anxiety (state- and trait-anxiety).

To assess participants' subjective stress levels, a Visual Analogue Scale (VAS) was used ranging from 0 (*not stressed at all*) to 100mm (*very much stressed*).

Four videos, two of crime (hostage robbery and domestic violence) and two neutral (a couple walking by the sea and a team of photographers working in a historic city) were randomly presented.

For each video, a set of six questions was applied: five without misleading information and one with misleading information in order to assess spontaneous and induced errors.

2.3 Design and Procedure

Three pilot studies were conducted. The first pilot aimed the videos selection for the experiment ($n = 10$). Alho and colleagues [35,36] have developed several studies exploring the nosewitness (psychology of testimony) and the authors used five videos of crime and five neutral scenes. For this experiment, a panel of ten independent raters (5 men, aged between 20 and 31 years, *M* = 24.5, *SD* = 2.8;

and 5 women, aged between 19 and 30 years (*M* = 25.2, *SD* = 3.1)) rated all videos from the studies of Alho and collaborators in 5-point Likert scales in terms of vividness, arousal and pleasantness. The two crime videos rated as more vivid (crime video #1, *M* = 4.6; *SD* = 0.5, crime video #2, *M* = 4.0, *SD* = 0.5), arousing (crime video #1, *M* = 4.7, *SD* = 0.5; crime video #2, *M* = 4.5, *SD* = 0.5) and unpleasant (crime video #1 *M* = 1.2, *SD* = 0.4; crime video #2, *M* = 1.6; *SD* = 0.7) were selected to the emotional condition (experimental group). The crime video #1 is a situation of taking hostage with the robber being killed by the police. The video #2 shows a domestic violence situation in which a man assaults a woman to try to get her out of the car. The two neutral videos rated with less arousing (neutral video #1, *M* = 2.0; *SD* = 0.7, neutral video #2, *M* = 1.8, *SD* = 0.4) and medium pleasantness (neutral video #1, *M* = 3.0; *SD* = 0.8, neutral video #2, *M* = 2.5, *SD* = 0.5) and vividness (neutral video #1, *M* = 3.3; *SD* = 0.7, neutral video #2, *M* = 3.6, *SD* = 0.5) were selected to the neutral condition of our experiment. The neutral video #1 is a couple walking by the sea and the neutral video #2 is a photographic team working in an historic city. These neutral situations are based on daily life and the intent is to not provide emotion or arousal.

The second pilot study ($n = 10$) was performed in order to select the questions that might increase suggestionability and create spontaneous and induced memory errors (misleading information). Six questions were created for each film: five without misleading information (spontaneous errors), and one key-question with misleading information (induced errors). In each question, participants had the possibility to respond with *Yes*, *No* or *Don't know*. Ten participants (5 men between the 19 and 28 years (*M* = 24.2, *SD* = 2.6) and 5 women between 19 and 32 years (*M* = 26.2, *SD* = 4.1) visualized each of the four selected videos and wrote all the things they remember from the scene (crime and neutral). In order to later be able to compare the amount of details remembered and reported by the participants, an information matrix was elaborated by the researchers, considering all the peripheral and central details. The details mentioned by all the participants in this pilot were selected to create the questions.

A third pilot study was conducted, in which three university students performed the task to test the procedure. None of the participants in the pilot studies have performed the experimental task to avoid any expected biases.

In a between-subject design, participants ($n = 80$) were randomly assigned to one of the two conditions: emotional (crime) and neutral scene. Participants filled a questionnaire with sociodemographic data, as well as STAI-Y1

and Y2 [29] and VAS [37].

Participants were informed that they would watch a real video using headphones, since visual and auditory cues promote greater ecological validity and increment the emotional tone of crime videos. Sound volume and video resolution were constant for all participants.

The videos were presented on a TOSHIBA Satellite computer (L850-1P9) of a 15.6-inch monitor. All the presented videos had an average duration of 60 seconds. A fifteen-minute retention interval (RI) was followed. After the video participants were asked to fill the VAS (stress) and STAI-Y1. In order to fulfill the 15-minute RI, they were also asked to complete the Thinking and Creating Styles Scale [38]. The results of this scale will not be presented, since it was used only as a distractive task.

Subsequently, participants performed a free recall task [39]. In this task, participants were instructed to report all the details they remember of the video they watched. After, participants were given a questionnaire about the video to determine the production or not of memory errors. Finally, participants were asked to complete the stress and anxiety scales to ensure that none of the participants was in distress.

3. Results

For the statistical analysis, the IBM SPSS Statistics 22.0 was used. ANOVAs, chi-square tests, independent and paired t-tests, and Pearson correlations were performed.

3.1 Stress and anxiety levels

Mixed repeated measures ANOVA was performed for the stress levels between the three moments (before/beginning of the task, after the video/post-film and at the end of the task). We verified an interaction between the stress and the nature of the films (crime vs. neutral), $F(2,156) = 10.57, p < .001$. Since there was an interaction between the stress and the condition of the film, paired t-student tests were performed for each condition. In the crime condition, post-film stress was higher compared to the stress levels in the beginning of the task and this difference is statistically significant, $t(39) = 3.76, p < .001$. There was also a difference between the stress levels in the beginning of the task and the stress levels at the end of the task with this difference being statistically significant, $t(39) = 3.73, p < .001$. This means that crime videos increased participants' stress levels, as expected, by their emotional nature.

Regarding the neutral condition, there was a marginal statistically significant difference, $t(39) = 2.03, p = .05$, between the stress levels at the beginning of the task and the stress levels at the end of the task. However, although

stress levels have increased throughout the experimental task, they were not high. Therefore, neutral videos did not trigger emotional reactions, which was expected. See Table 1 for descriptive values.

Table 1. Means (and SD's) obtained in the VAS (Stress) by video condition, in the following moments: before the task, after the video, and at the end of the task

	Before the task	After the video	End of the task
Crime condition	1.74 (2.24)	2.98 (2.81)	2.44 (2.41)
Neutral condition	2.20 (2.54)	1.92 (2.24)	1.77 (2.02)

Mixed repeated measures ANOVA was performed for the state-anxiety and trait-anxiety. There was an interaction between anxiety-state and the nature of the films, $F(2,156) = 3.32, p = .04$. As so, paired t-student tests were performed. In the crime condition, there were statistically significant differences between the initial state-anxiety ($M = 33.88; SD = 7.80$) and the post-film state-anxiety ($M = 37.58; SD = 9.91$), $t(39) = 3.37, p = .02$. In the neutral condition, there were no statistically significant differences in state-anxiety in any of the three moments ($p \geq .05$). Concerning trait-anxiety there were no statistically significant differences ($p \geq .05$), nor was there a significant interaction between state-anxiety and the nature of the videos (neutral and crime).

Thus, results suggest that after visualizing the crime videos the levels of state-anxiety and stress increased significantly, but trait-anxiety levels were maintained, since the trait is a relatively stable individual characteristic. See Table 2 for descriptive values.

Table 2. Means (and SD's) obtained in the state-anxiety and trait-anxiety by video condition in the following moments: before the task, after the video, and at the end of the task

	Before the task	After the video	End of the task
Crime condition			
State-anxiety	33.88 (7.80)	37.58 (9.91)	35.70 (10.65)
Trait-anxiety	36.90 (9.52)	36.80 (10.71)	36.25 (11.61)
Neutral condition			
State-anxiety	35.95 (9.98)	35.90 (9.47)	34.57 (7.51)
Trait-anxiety	37.32 (11.01)	36.48 (10.58)	35.92 (10.28)

Pearson correlations between the stress levels at the beginning of the task, after the video and at the end of the test and memory errors were performed. The correlations were not significant ($p \geq .05$). The same analysis was done for state-anxiety, trait-anxiety and memory errors and there were no significant correlations ($p \geq .05$), suggesting

that there is no correlation between stress and anxiety with memory errors.

3.2 Spontaneous Errors

Each participant visualized a video and had to answer questions about it. Each questionnaire had six questions and one of them was an error-inducing question, with misleading information, while the other questions had no misleading information (to assess spontaneous errors).

Regarding crime video #1 (hostage robbery), in the error-inducing question, 30% of the participants had a memory error, i.e., they assume the information integrated in the question was right, and 55% of participants preferred to answer "don't know". However, the greater percentage of errors (40%) was observed in a question without any misleading information (spontaneous errors).

Regarding the crime video #2, it was found the same percentage of memory errors compared with the first crime video (30%), but it was observed a higher percentage of correct answers (45%). Results showed spontaneous errors in every question, varying between 10 to 30%.

In the neutral video #1, results showed that 15% of participants assumed the misleading information as correct. However, it was in a regular question, without misleading information that participants presented more errors (40%).

Finally, in the neutral video #2, results showed the same percentage of errors as in the neutral video #1 (15%). Moreover, the highest percentage of spontaneous errors was 30%.

A Chi-square test was performed and results showed more errors in the crime condition compared to the neutral condition with respect to the questions with misleading information, with this difference being statistically significant, $\chi^2(2) = 6.109, p = .047$.

With regard to the free recall task, paired t-student tests were performed to compare means in recalling central and peripheral details within the two conditions. In the crime condition, there were more central details remembered than in the neutral condition, with this difference being statistically significant, $t(78) = 4.076, p < .001$. Moreover, in the neutral condition, the peripheral details were more remembered than in the crime condition, but this difference is not statistically significant ($p \geq .05$). See Table 3 for descriptive values.

Table 3. Means (and SD's) for central and peripheral details recalled by participants in each condition

	Crime condition	Neutral condition
Central details	3.78 (2.14)	2.09 (1.51)
Peripheral details	2.73 (1.22)	3.19 (2.46)

3.3 Sex Differences

No statistically significant difference was found between men and women regarding the stress and anxiety levels ($p \geq .05$).

To verify if there were differences between women and men for the misleading questions, chi-square tests were performed. The results showed that men made more induced errors than women. This difference was statistically significant, $\chi^2(2) = 6.627, p = .036$.

In the neutral condition, results showed no significant differences in the performance of men and women, $p \geq .05$.

Regarding the free recall task independent t-student tests were performed to compare the differences between gender with the central and peripheral details, considering the two conditions. For the crime condition no significant difference was found between men and women in the recall of central and peripheral details ($p \geq .05$). In the neutral condition, women reported a greater number of peripheral details compared to men, a marginal statistically significant difference ($p = .05$).

4. Discussion

Memory is fallible and that is the main reason why innocent people are wrongful convicted. In the present study we aimed to determine if there was an influence of stress and anxiety on memory errors using real scenes.

We hypothesized that high stress and anxiety levels compromise memory, leading to more errors. However, there was no relation between stress and anxiety levels with memory errors. Our results do not support the idea that stress or anxiety have a positive or negative impact on memory. In fact, the results obtained were not in agreement with the existing literature which, in one hand, shows the negative influence of these variables on the memory errors^[19, 20], and in the other hand, that stress or anxiety may improve the memory of witnesses, because individuals are usually predisposed to be more attentive to what is happening^[23, 25]. Our results maintain the debate about the impact of these variables in recalling events with emotional content.

Although there was no relation between these variables with spontaneous and induced errors, it was observed, through VAS, that events with a negative emotional tone (crimes) triggers stress, that is, after seeing crime videos the stress levels increased. This result is congruent with the literature that states the existence of high levels of stress when witnessing a crime^[26]. However, for the neutral condition there were no significant changes, only a slight change was observed between initial and final stress.

For state-anxiety, the results of STAI-Y1 scale showed a significant increase after viewing the crime videos. Contrary to stress and state-anxiety, in STAI-Y2 (trait-anxiety) no significant differences were observed. This can be explained by the fact that it refers to an individual characteristic that is relatively stable^[28, 29], with no changeability during the experimental task.

Although there was no influence of stress and anxiety in memory, there were spontaneous and induced errors in the questions about the videos. While there was a high percentage of errors in the questions that had misleading information (induced errors), it was in the questions without misleading information that there was a greater percentage of errors (spontaneous errors). Participants were also given the chance to respond, “don’t know”, and these answers were not counted as errors. As a rule, when participants have closed-ended questions (yes/no), they end up spending more time thinking about this issue and may end up believing it to be a truth and making more mistakes^[40]. The answer “don’t know” does not force the participant to have to decide on the truth or falsity of an information, thus avoiding false positives. This methodology has been done in memory and offender recognition studies, both through interviews and through lineups^[22, 41, 42]. When we compare the questions with misleading information in both conditions, results revealed that the number of errors was significantly higher in the crime condition, according to the expected, that is, a crime situation adversely affects the memory of the participants^[43].

In the free recall task, participants in the crime condition remembered more central details compared to the neutral condition. This might be explained by the literature confirming that there is an improvement in the memory of central details in crime contexts rather than neutral ones, because emotionally arousing contexts improve recall of physical characteristics of the offender and the victims^[23, 24]. This is due to the negative emotional charge that causes a high focus of attention, which leads to an increase in the details^[23]. Although we have found no statistically significant differences, it should be noted that participants in the neutral condition recalled more peripheral details compared to those who viewed crime videos, guiding their attentional focus to the surrounding environment.

The details remembered by the participants were far below expectations when compared to our matrix. This allows us to conclude that the participants’ memory was weak in a short retention interval (15 minutes). However, in real context, the retention interval is usually considerably greater. It can often take years for a witness to be called to testify. The literature points to a decrease in memory with longer retention intervals^[3]. This expect-

ation may lead witnesses to provide biased information because of the degree of emotion in coding, at recall^[44], and because witnesses tend to fill memory gaps that occur over time^[5].

Regarding gender, in the free recall task, there were no relevant differences in the crime condition for details remembered by men and women. However, the responses given by the participants about the videos showed significant differences between men and women, in the crime condition, with men evidencing more errors. These results are in line with the existing literature that women have a better memory in crime context compared to men who give more errors^[33, 45]. Although it has not yet been well established, women can present a more accurate memory in crime contexts, because they are also the victims of crimes^[33].

One of the criticisms of laboratory eyewitness studies is the use of videos that may not generate the same levels of arousal and anxiety as when experiencing a real crime situation^[24]. Witnessing a traumatic event causes more impact than the visualization of a real event in a laboratory context. Nevertheless, this experimental study allowed to verify that there is an effective increase of the levels of stress and anxiety in a negative emotional event.

According to the literature, people remember more central than peripheral details when they experience a crime situation. This confirms that experiencing negative events may compromise the accuracy of the testimony^[46].

Even though there was no correlation between stress and anxiety with the errors made by participants, these variables, when experienced at high levels, can compromise memory. The increase of errors in the description of the event is related to increased anxiety^[21]. Anxiety and stress are experienced not only during the crime, when acquisition / coding is done, but also at the time of recovery at the interview^[19, 31].

Given that eyewitnesses’ mistakes have a great impact in judicial and societal domains, further investigation is needed in order to decrease these errors that may have serious repercussions.

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