LUNDS UNIVERSITET

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# Emotion and memory
# The role of facilitated episodic memory on memory errors

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# Abstract

The present study investigated whether emotions influence participants' memory judgements. A special attention was paid to episodic memory. The experiment investigated participants' memory for faces and its main goal was to study whether facilitated episodic memory could lead to a lowered susceptibility to memory errors especially in regard to negative faces. The experiment consisted of two blocks: a black-and-white block that was a simple recognition test, and a colour block that was a source memory test. The main idea was that tendency to temporal context confusion (TCC) had to decrease as a function of episodic memory. The present study measured episodic memory with the help of a source memory test. Based on previous research that showed facilitated episodic memory for negative faces in a recognition test, a decrease in TCC for negative stimuli was predicted. Reliable TCC was observed for all types of faces and even greater for negative faces. However, since there was no improved source memory performance for negative stimuli, the present study does not allow a conclusive test of the idea that episodic memory may lower the susceptibility to memory errors.



**Key words**: emotions, episodic memory, temporal context confusion, source memory.

# Introduction

There have been several attempts in order to define human emotion. According to Gazanniga, Ivry and Mangun (2002) these attempts can be described in two ways. The first attempt to define emotions is through the examination of the universality of facial expressions. By studying different cultures around the world one can find basic facial expressions that stand for basic human emotions, for example anger, and fear, happiness, surprise, disgust and sadness. Another attempt is to characterize emotions through motivation. For example, while feeling disgust the person will probably withdraw from engaging into the situation. On the other hand, the feeling of happiness may produce the opposite pattern. In general, according to many researchers no single approach can be called universal as much depends on the goals of every scientific investigation.

According to contemporary views emotions can be described as “action schemes that prepare the organism for certain behaviors” (Ward, 2006, p. 309). Emotions differ from moods that are described by the same author as situations in which a certain emotion reoccurs. For example, the emotion of fear usually occurs in connection to anxiety.

In the frame of neuroscience it has been of primary interest to examine how emotional events are encoded and remembered in the human brain. The interaction between emotion and memory has become a dominant area for investigation with interesting discoveries emerging to the scene. It has been shown that emotion influences both learning and memory in a way that makes multiple brain systems react differently at various stages of information processing: encoding, consolidation, storage and retrieval. The role of the amygdala has been emphasized in regard to these stages (LaBar & Cabeza, 2006).

LeDoux (1999) describes the amygdala as a brain structure that is responsible for processing emotional stimuli. He points out that it responds very quickly and early in the processing of these stimuli. The role of the amygdala in emotional memory tasks has been investigated. Such terms as arousal and valence have been introduced. Arousal has been described in terms of a dimension of emotion that can vary from calm to excitement. Valence has been described as a dimension of emotion from unpleasant to pleasant or neutral. The idea that arousal not the valence itself is the crucial factor in engaging the amygdala during emotional memory has been supported by findings in research on patients with amygdala lesions.

Patients with amygdala lesions show the following impairments. First, they do preferentially remember words that are affectively valent but low in arousal in comparison to neutral ones, as well as neutral words encoded in emotional sentence contexts in comparison to neutral context. Second, patients with Urbach-Wiethe syndrome show impairments in long-term recall or recognition of emotional material such as words, pictures and stories. Long-term recall covers periods from 1 hour to 1 month. Moreover, they do not focus on central gist information when memory is tested for audiovisual narratives that describe emotionally arousing events (LaBar & Cabeza, 2006). Some other consequences of amygdala damage have become evident: the same patients show "impaired recognition of emotion in facial expressions" (Adolphs, Tranel, Damasio & Damasio, 1994, p. 670).

The role of the amygdala in regard to hippocampal activity should be emphasized. The amygdala and hippocampus are structures located in the medial temporal lobe. It has been suggested that the amygdala influences memory processes through hippocampal activity and interaction with prefrontal cortexes and additional cortical regions (Dolan, 2002). Through these projections, the amygdala influences ongoing perceptions, mental imaginary attention, short-term memory, long-term memory and working memory. In other words, amygdala functions as a necessary mediator of emotional influences on perception. The damage of hippocampus can lead both to retrograde and anterograde amnesia. Research reviewed by Simons and Spiers (2003) emphasize the role of hippocampus in episodic memory by showing that "new connections between hippocampus and neocortical areas are created every time an episodic memory trace is retrieved" (p. 639). Moreover, bilateral surgical resection of the medial temporal lobes and partial removal of hippocampal structures to relieve epilepsy, mentioned by the same authors in their article, resulted in inability to store new episodic long-term memories.

Some special attention should be paid to the interaction between the amygdala and the prefrontal cortex. The prefrontal cortex and the amygdala function as two systems in interaction. The prefrontal cortex contains the orbito-frontal cortex that controls emotions and memory functions. Amygdala, the so-called alarm system, stands for recognizing emotionally salient stimuli, for example, recognizing negative faces.

Damage to the orbito-frontal cortex leads to an impairment in control functions, although the ability to learn something new remains intact. Patients with the damage to the orbito-frontal cortex are often out of reality, they can recall things that happened in their lives but they do not possess “the ability to distinguish between memories that pertain to ongoing reality and memories that do not” (Schnider, 2003, p. 664). The case study of Phineas Gage shows that damage to the orbito-frontal cortex may lead even to personality change as in his case from a kind person to an aggressive type. This case indicates also that “mind functions can be linked to specific brain areas” (Damasio, 1994, p. 38).

The interaction between the amygdala and the prefrontal cortex has been emphasized by. LeDoux (1999). According to him amygdala stands for acquisition of fear conditioning but when it comes to normal extinction of a conditioned response the interactions between the amygdala and the prefrontal cortex are needed.

LeDoux (1999) considers that the amygdala responds to fear much faster than the cortex. He admits the fact that in kids, the amygdala develops before the hippocampus, the brain structure that forms conscious memories. The latter fact explains why a child who was abused keeps unconscious emotional memories for fear through all life without being able to explain his/her fears verbally. This explains also that amygdala matures before the hippocampus.

In general, the researcher considers that the amygdala has a greater impact on the cortex than the cortex has on amygdala. The latter fact allows emotional arousal to dominate and control thinking. At the same time, he considers that “the cortical connections with the amygdala …continue to expand, allowing future humans to be better able to control their emotions [and] …allowing cognition and emotion work together rather than separately” (LeDoux, 1999/2004, p. 303).

Amygdala plays a huge role in episodic memory. It is engaged in episodic memory for emotional material. Episodic memory is defined as “the portion of long-term memory in which personally experienced information is sorted” (Ashcraft, 2006, p. 568). In other words it can be defined as one’s autobiographical long-term memory. It is contrasted with semantic memory that is described by the same author as the long-term memory component that is comprised of world knowledge, including knowledge of language.

For the present study, the term episodic memory is of a primary importance. Some previous research showed facilitated episodic memory for negative faces in a recognition test. One of the major goals of the present study was to examine whether or not a facilitation of episodic memory results in a greater decrease of temporal context confusion (TCC), especially when it comes to faces that express negative emotions. In other words, the main idea was to examine whether or not a tendency to TCC decreases as a function of episodic memory.

The present study investigated the interaction between emotion and memory while participants were processing human faces. The accuracy of emotional memories has been previously investigated by many researches. Some studies confirm high memory accuracy for both traumatic and extremely positive events. Some other studies imply that some emotional memories do contain errors as in case with “flashbulb memories” described by Brown and Kulik in 1977. Flashbulb memories have been defined as “the exceptionally clear and detailed recollection people seem to have for singular, emotional, and consequential events they have experienced” (Reisberg & Hertel, 2004, p. 5), for example, the John Kennedy’s assassination. They can be particularly accurate but several studies show that "flashbulb memories" can contain errors or can be totally mistaken. Such impaired memories are often called false memories because they are either partly or totally wrong, but are accepted as real memories by the individual who is doing the remembering.

There have been several attempts to explain why people have strong memories in one case but not in the other case. Reisberg and Hertel (2004) suggest several explanations. The first explanation touches upon the weapon focus effect that describes the witnesses to crimes as individuals who "lock" their attention onto the criminal's weapon and do not pay the same attention to anything else around. The weapon focus effect corresponds with the so-called Easterbrook hypothesis, stating that arousal causes a narrowing of attention so that an aroused organism pays less attention to information at the "periphery" of an event but more attention to information at the centre of the event.

Another explanation touches upon the source of the emotion. The distinction between thematically induced and visually induced emotion reveals the problem of generalizability. Visually induced emotions can not represent emotion as it naturally occurs outside laboratory. For example, reading an article about an airplane crash in which nobody survived (visually induced material) does not produce the same emotional effect as a real fact about an illness you might have that affects you personally.

One more explanation is connected to the type of the emotion. Emotion intrinsic to the event differs from the emotion extraneous to the event or emotion that accompanies the event. Christianson and Mjörndal (1985) have come to the conclusion that "the arousal does matter and that only arousal intrinsic to the to-be-remembered materials has memory effects" (pp. 237-248). In contrast, however, Reisberg and Hertel (2004) show that "ingestion of glucose improves memory in some circumstances" (p. 19), emphasizing a general effect without focusing on what is going to be remembered is emotional.

Further, the same researches suggest that attention narrowing is only possible with "a salient stimulus" that will lock participants' attention. They consider that the meaning of the stimulus depends on the emotional context. Moreover, this emotional meaning depends on every particular emotion that is experienced by an individual. It means that different individuals will perceive the same stimulus differently. For example, a stimulus salient for someone who is sad may well be less salient for someone who is furious.

Having described studies dedicated to memory accuracy, it is high time to proceed with presenting some results obtained from different tests that investigated memory abilities. Interestingly, recognition memory tests (in which participants must decide whether a stimulus was or was not shown on a particular occasion) reveal the following results for emotional material. The ability to differentiate between new and old stimuli (Pr) is not higher for emotional stimuli. The increased hit-rate (correct answers) is accompanied by the increased false-alarm rate thus making the results less consistent in comparison to studies of recall (in which participants must produce previously seen stimuli without a full prompt being given). In the studies of recall an emotion-induced memory enhancement is observed more consistently.  Figure 1 shows the four–cell matrix that results when combining the two response alternatives "old" and "new" with the actual status of the presented information, that is, old and new.

| | **Response** | |
|---|---|---|
| **Item status** | **old** | **new** |
| **old** | Hit | Miss |
| **new** | False alarm | Correct rejection |

**Figure 1**. The four-cell matrix.

In regard to answering alternatives, there are two behavior patterns: conservative, resulting in more misses and liberal, resulting in more false alarm rates. An event-related potential study on recognition memory for emotional and neutral faces indicated that emotional faces are "associated with a more liberal response bias than neutral faces and further that the two types of emotional facial expressions differ in a negative more liberal than positive pattern" (Johansson, Mecklinger & Treese, 2004, p. 1843). However, no conclusive account for this pattern, which is described in literature as the emotion-induced recognition bias, has been found. Instead, different suggestions have been proposed. One of them states that control functions in the prefrontal cortex are influenced by emotion, supporting a flexible criteria setting.

According to Mandler (1980), recognition memory is based on two processes: recollection and familiarity. Recollection is defined as "context-dependent memory that involves remembering specific information from the study episode" (Ward, 2006, p.191). In the present study recollection/ episodic memory is examined. Familiarity is defined by the same author as a context-free memory in which the recognized item just feels familiar. Both familiarity and recollection are supposed to support recognition memory.

According to Yonelinas (2002), familiarity and recollection function as two independent processes. According to his model familiarity can be represented as quantitative retrieval and recollection as qualitative retrieval. Emotions influence recognition by inducing the so-called recognition bias that in short can be explained as a tendency of participants to respond to a negative item as "old" in comparison to an emotionally neutral item irrespective of whether it is "old" or "new".

Returning to Schnider, it is important to describe his memory experiment that examined the ability to distinguish between memories that belong to ongoing reality and memories that do not. In short, the experimental task can be described in the following way. In the first run, where a long series of pictures with some pictures repeated was presented, the subjects had to indicate picture recurrence. In the second run, which comprised the same pictures presented in another order, they were asked to forget what they have already seen in the first run and to indicate picture recurrence only in the second run. The repetition of the task played a huge role in the experimental task. It showed that not only familiarity is involved but also that the ability to differentiate between ongoing reality and past events determines task performance.

The results showed the type of mistakes that were done by the subjects. Temporal context confusion increased, especially when it came to the second run and it was greater for the patients with orbito-frontal lesions than healthy subjects. The results from Schnider's experiment suggest that it might be informative to relate the type of control function that orbito-frontal patients lack to the type of the memory error that is induced by emotion-induced recognition bias.

It is important to mention that TCC is said to appear because of a lack in prefrontal control of the relevance of memories and also because emotion-induced recognition bias may result from influenced control functions in the prefrontal cortex.

In the present study it is interesting to manipulate the factor of emotion because of the practical appliance that may come from the results, namely that facilitated episodic memory (recollection) can protect subjects from temporal context confusion: the type of mistake that is characteristic to the task.

## Purpose and hypothesis

With the background of the empiric research that has been presented above it is of a great importance to investigate further the interaction between emotion and memory while processing human faces with various facial expressions: negative, positive and neutral. The research is narrowed down to a specific purpose to measure episodic memory with the help of a source memory test. Bearing in mind previous studies that showed facilitated episodic memory for negative stimuli, the main hypothesis has been stated. The main hypothesis of the present study is that facilitation of episodic memory leads to a decrease in memory mistakes associated with human faces with negative facial expressions.

# Method

## Participants

This study is based on the results obtained from 32 students at different departments at Lund University who participated in an approximately 1 hour and 15 min long experiment. Out of 32 participants there were 16 men and 16 women. Participants were between 20 and 34 years old. The mean age for men was 26, 4 and for women 23. The mean age for both groups was 25. All the students participated on a voluntary basis, though a small compensation was offered. The participants were recruited during their lecture time in a lecture hall or during breaks in the university.

## Material

The faces in the experiment were taken from two databases, namely from Lundqvist & Litton (1998) and from Treese, Brinkmann, & Johansson (2003).
Human faces were presented in a long sequence at the centre of the screen. Each sequence presented faces with various facial expressions as shown in figure 2.

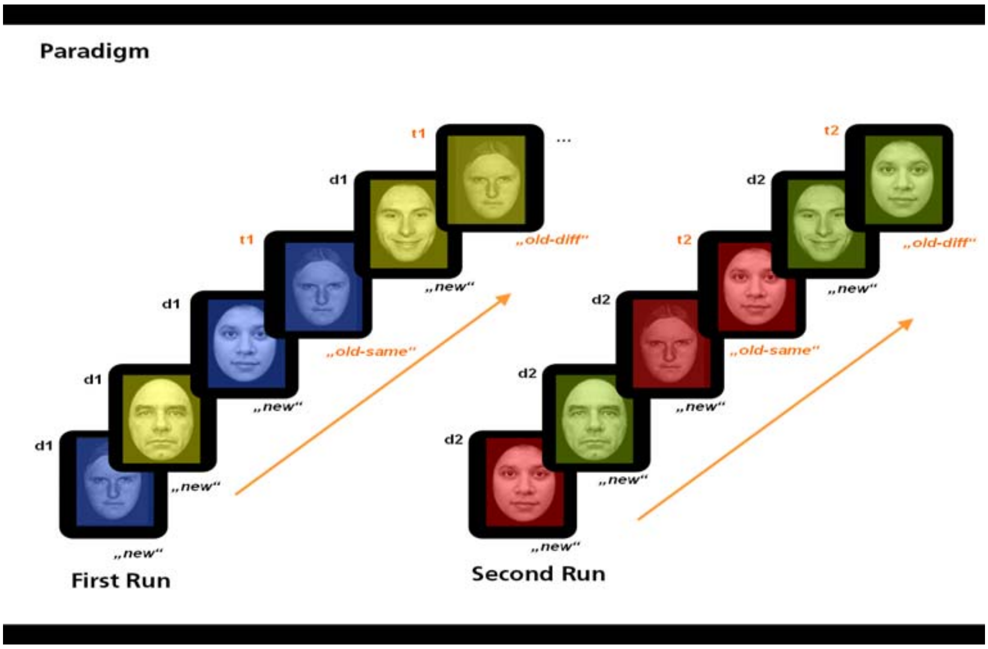


**Figure 2.** Human faces with various facial expressions in different runs.

The experiment was subdivided into two blocks: black-and-white block and a colour block. Every block consisted of 30 faces, so totally there were 60 individual faces that were included in the following paradigm: 30 "new" faces and 24 "old" faces for each emotion category, 12 distracters were repeated, 18 were never repeated. Overall there were 162 presentations per run (every first run had 167 trials including targets (faces that were controlled for), distracters (faces that distracted participants), and filler items). Moreover, in each first run there were 5 filler faces to give participants the opportunity to learn the key assignment.

It is important to mention that in a colour block faces were presented in the following colours: blue (50%) or yellow (50%) in the first run and red (50%) or green (50%) in the second run. The main purpose of such a change was to minimize confusion from the first run. In the whole experiment, each face was presented in all five colours: black-and-white, green, yellow, red and blue as shown in figure 3.

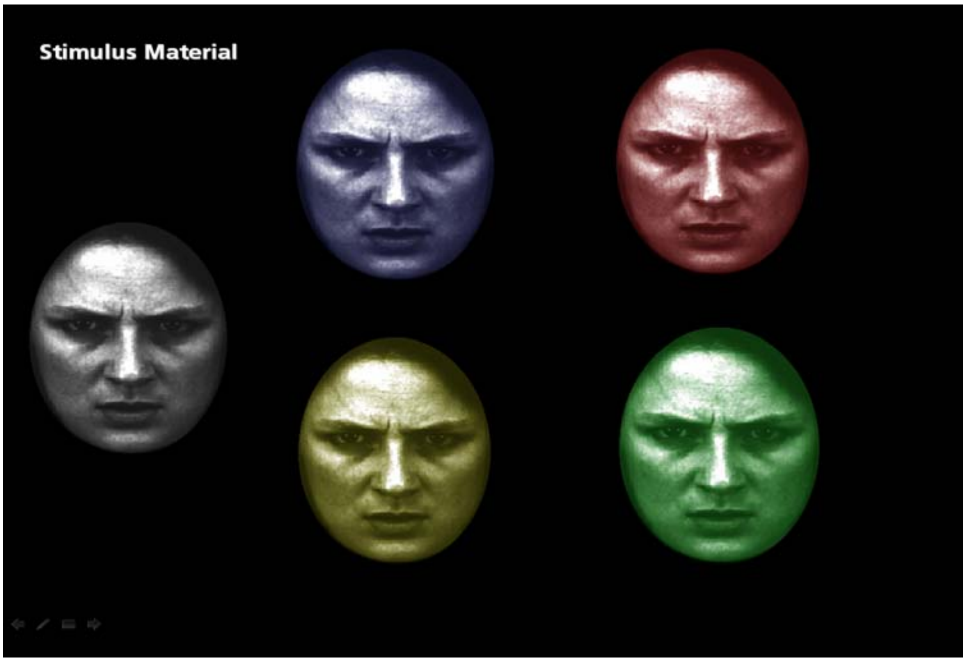


**Figure 3**. Stimulus material used in the experiment.

## Procedure

Participants were invited to an experimental laboratory with several computers. Experimental conditions allowed three participants to do the experiment simultaneously. Participants were informed that they were not allowed to talk during the experiment, and that they had to turn off their cell phones.

During data gathering the legitimacy of answers was controlled. Participants who pushed tangents on the keyboard that were not marked with stickers, or who were continuously answering during the wrong point of a presentation sequence were substituted by other students in order to be aware that all the answers have been registered by the system in a correct way and to avoid misinterpretations.

Before the experiment the participants were asked to carefully read through the instruction in a paper form. While reading the main instruction, participants were sitting in a computer room with lights on. Having finished reading the instruction, participants were informed that the light would be turned off and a laboratory lamp would be used instead. In the instruction participants got to know that the experiment would investigate memory for faces. It was stated further that the experiment would consist of two main blocks: a black-and-white block where faces would be presented in black and white, and a colour block where faces would be presented in colour. The participants also read that each block would be subdivided into two sub-parts, and that there would be a short break after each sub-part. The fixation cross was used in order to help participants to focus on every next face that was appearing on the screen as shown in figure 4.

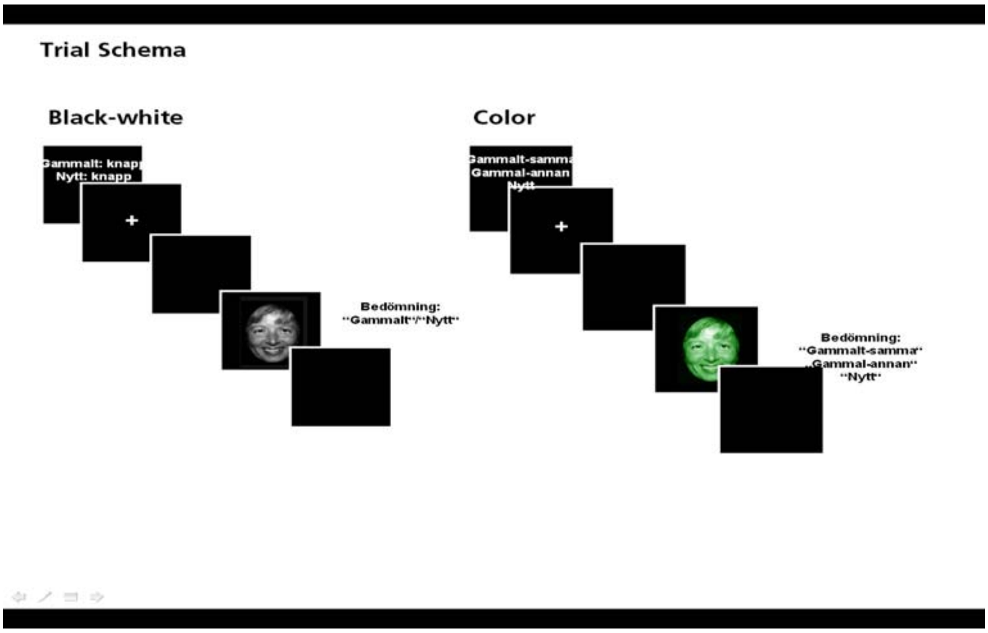


**Figure 4**. Trial Scheme

Each trial comprised the following events: a task cue with instructions about response buttons (2000 ms), a fixation cross (1000 ms), the face presentation with response collection (2500 ms), and a blank screen (1000 ms). Each trial took 6.5 s., each sub-part took 17 min, and all 4 parts took 70 min.

In black-and-white block the participants were asked whether the picture was "new"/presented for the first time or "old" /repeated in the same sequence. As far as the colour block is concerned, the participants were asked to judge whether the face was "new" or "old-same"/repeated in the same colour or "old-dif"/repeated in another colour. The participants were asked to make their judgements in relation to the previous presentation in a sequence.

In addition to the main instruction, the participants read a separate instruction on the screen that was preceding each sub-part. The participants started every sub-part themselves by pressing the space bar. Another important aspect for the participants was the fact that each sub-part should be treated separately. In other words, the participants had to use the same principle all the time: press "new" for each new item and "old" for each repeated item in every sequence, so even if a face was remembered from the previous sequence the participants had to make their judgements in regard to the present sequence, and press "new" for each item that was shown for the first time in this particular presentation irrespective of the previous presentations.

Counterbalancing covered three main aspects: order of block presentation: colour block vs. black-and-white block, response keys and target-status. As far as the first aspect is concerned, half of the subjects started with the colour block and continued with the black-and-white block afterwards, while the other half started with the black-and-white block and afterwards did the colour block.

The response keys were also counterbalanced: for the colour-block the participants had 3 keys to press: new, old-same, old-diff and for the black-and-white block they had 2 keys to press: old and new. Half of the subjects had the old-left side to use and the other half the old-right side to use. Within these two halves the response keys in the colour block were also counterbalanced as shown in figure 5.

| Run1 | Run2 | Block | Subject number | | | | | | | | Instr | old | new |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Run1_A1_l<br>Run1_B1_l | Run2_A1_l<br>Run2_B1_l | Colour<br>BW | 1 | 5 | 9 | 13 | 17 | 21 | 25 | 29 | Oldleft1<br>Oldleft | f = same, s = diff<br>f | j<br>j |
| Run1_A1_r<br>Run1_B2_r | Run2_A1_r<br>Run2_B2_r | Colour<br>BW | 2 | 6 | 10 | 14 | 18 | 22 | 26 | 30 | Oldright1<br>Oldright | j = same, l = diff<br>j | f<br>f |
| Run1_B1_l<br>Run1_A2_l | Run2_B1_l<br>Run2_A2_l | BW<br>Colour | 3 | 7 | 11 | 15 | 19 | 23 | 27 | 31 | Oldleft2<br>Oldleft | f = diff, s = same<br>f | j<br>j |
| Run1_B2_r<br>Run1_A2_r | Run2_B2_r<br>Run2_A2_r | BW<br>Colour | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | Oldright2<br>Oldright | j = diff, l = same<br>j | f<br>f |

**Figure 5**. Design of the experiment

It is important to mention that tangents f, j, l and s were marked with the corresponding stickers a, b, c and d that were framed in a black square for better perceiving.

Target-status was counterbalanced as well in order to be aware of the fact that all faces got target status.

# Results

Participants' memory performance was analyzed using repeated measures analysis of variance (ANOVA), employing the factors of emotion (positive, negative, neutral), and task (black-and-white block vs. colour block). Such measures as discrimination accuracy and response bias were examined always in run 1 because exactly these measures contain new stimuli that are demanded for their meaningfulness. TCC measures difference between run 1 and run 2 regarding the tendency to make false alarms. The factor of run was used only in the source memory analysis.

The analysis of discrimination accuracy (Pr = Hits – False alarms) revealed a main effect for "emotion": [$F(2,62) = 6.43$, $p = .003$]. Planned pairwise comparisons showed that positive and negative faces did not differ significantly while there was a significant difference between positive/negative and neutral faces as shown in figure 6.

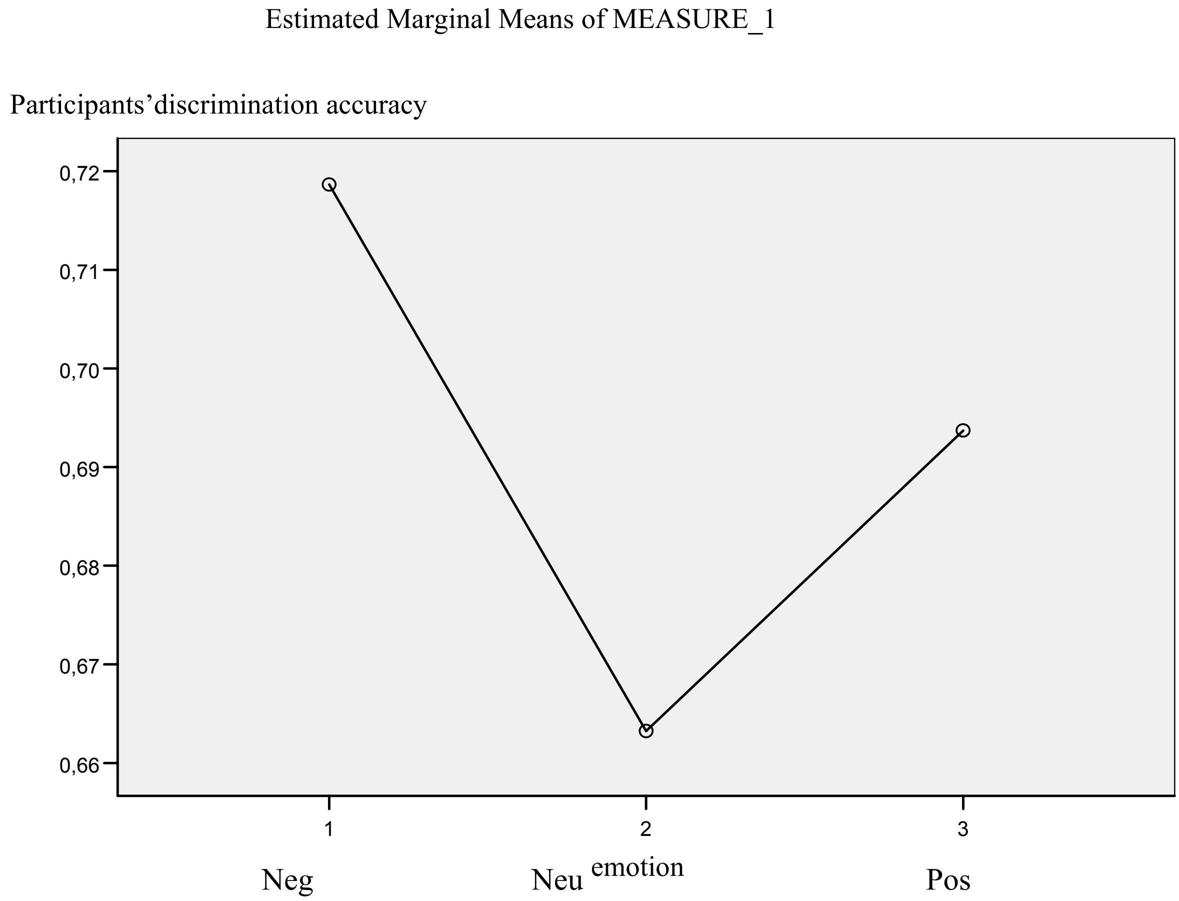


**Figure 6**. Participants' discrimination accuracy as function of emotion.

The analysis of the response bias measures (Br = FAs/ (1-Pr)) revealed a greater response bias for negative faces in a colour block in comparison to black-and-white block. A repeated measures analysis of variance (ANOVA) did not show any main effect of emotion: [$F$ (2,62) = 1.26, $p$ = .29]. It showed a marginally significant interaction between task and emotion: [$F$ (2,62) = 4.55, $p$ = .14] as shown in figure 7.

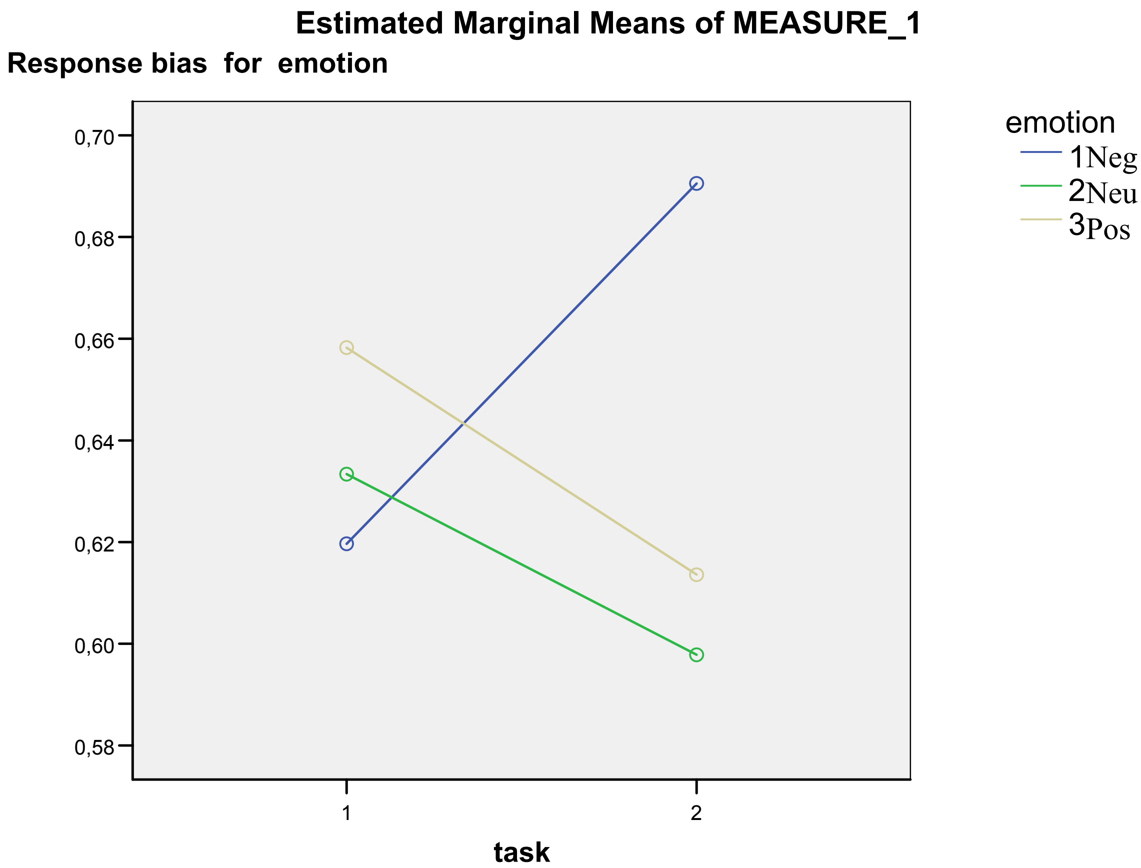


**Figure 7**. Interaction between task and emotion (negative, neutral and positive faces).

The interaction indicates that response bias depends on the task that the participants perform. The effect of emotion exists only in the colour task. In other words, emotion-induced recognition bias can be observed only in the colour task. It is interesting that the present interaction shows a decrease for both neutral and positive faces and a totally different result for negative faces. Planned pairwise comparisons showed that negative faces were associated with a more liberal response bias than neutral and positive faces.

The described above results are also presented in diagrams in figures 8-10.

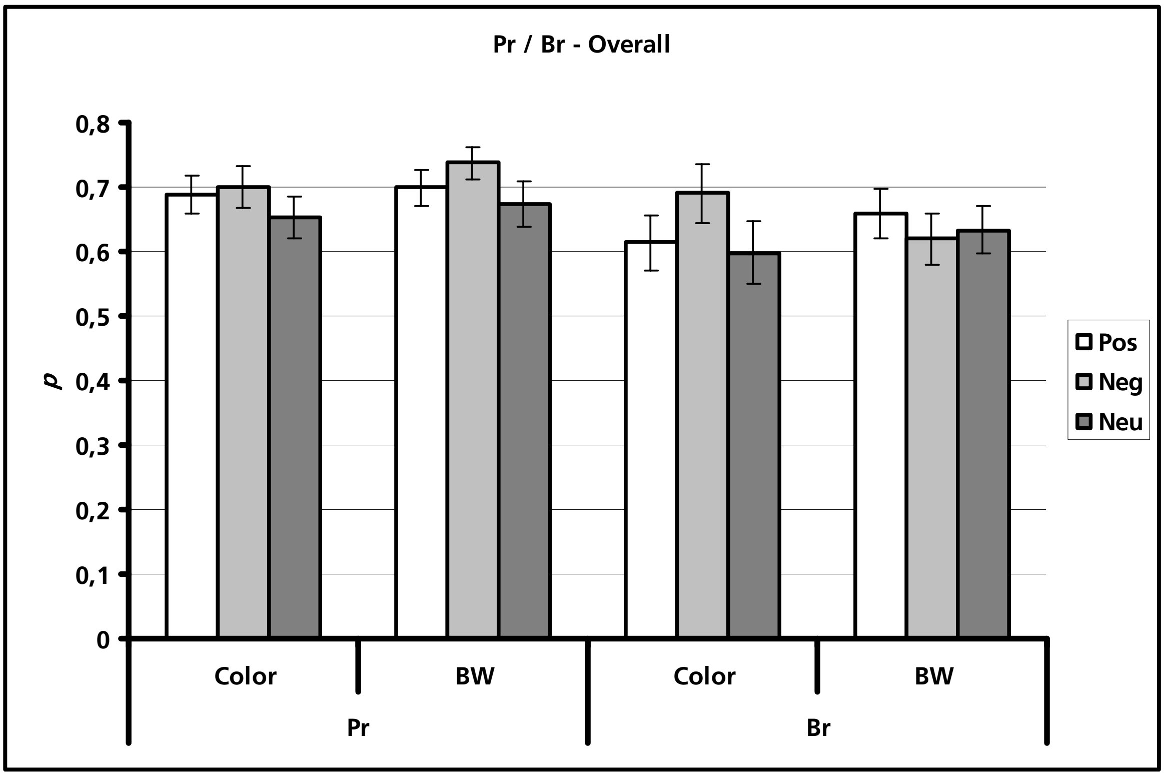


**Figure 8**: Participants' discrimination accuracy and response bias for positive, negative and neutral faces in the colour and black-and-white block in run 1.

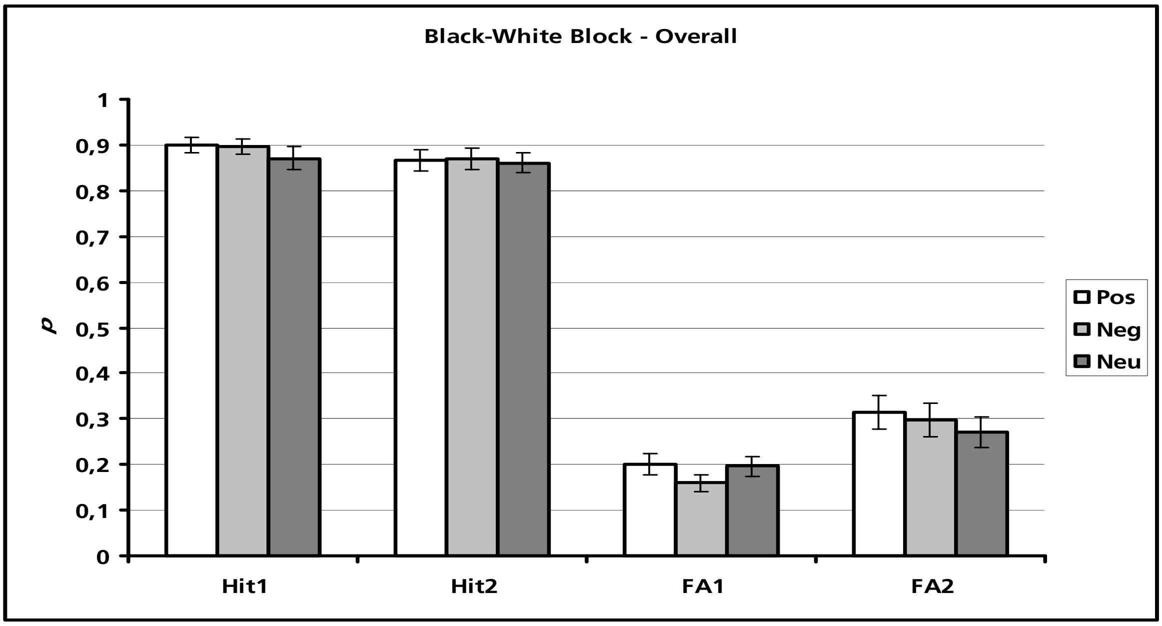

**Figure 9**: Overall hits and false alarms for different emotional stimuli in a black-and-white block run 1 and 2.

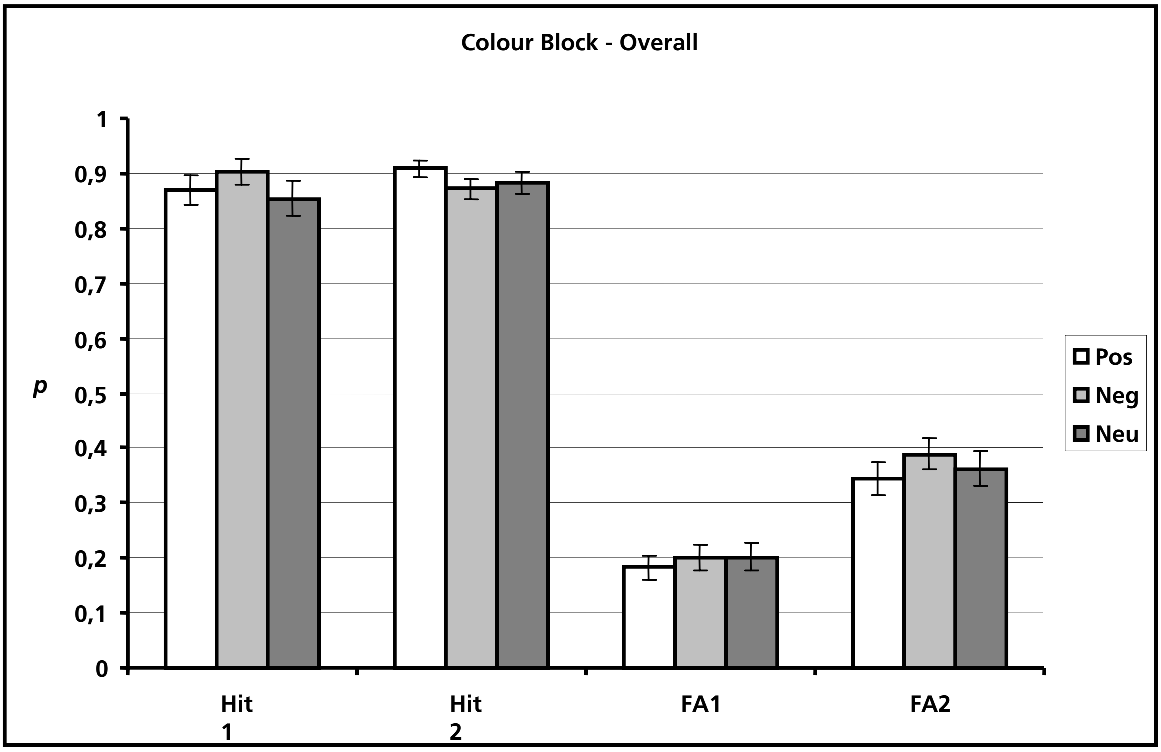


**Figure 10:** Overall hits and false alarms for different emotional stimuli in a colour block in run 1 and 2.

In order to assess participants' episodic memory for the previous presentation of a face, source memory performance has been investigated. Source memory performance means that source judgements have been taken into consideration: whether correct source judgements have been produced (correct face– correct colour) or whether correct source judgements with incorrect colour have been produced (correct face – incorrect colour).

A repeated measures analysis of variance (ANOVA) of source accuracy employed the two factors of run (1 or 2) and emotion (positive, negative and neutral). The analysis did not show any significant main effects or interaction [$F < 1$, *ns*]. Thus, source memory performance was not influenced by facial affect.

Participants' temporal context confusion can be presented in the following way. TCC was induced for all emotion categories. It is important to mention that TCC that is equal to 0 means absence of confusion.

The repeated measures analysis of TCC measures (TCC = (FA2/Hits2) – (Fa1/Hits1)) showed a marginally significant effect of "emotion" [$F$ (2, 62) = 5.21, $p$ = .008]. No main effect of "task" nor an interaction between the two factors were found: [$F$(2,62) = 1.14, $p$ = .326]. Planned pairwise comparisons showed that negative faces were associated with a greater TCC as compared to neutral and positive faces (see Fig. 11).

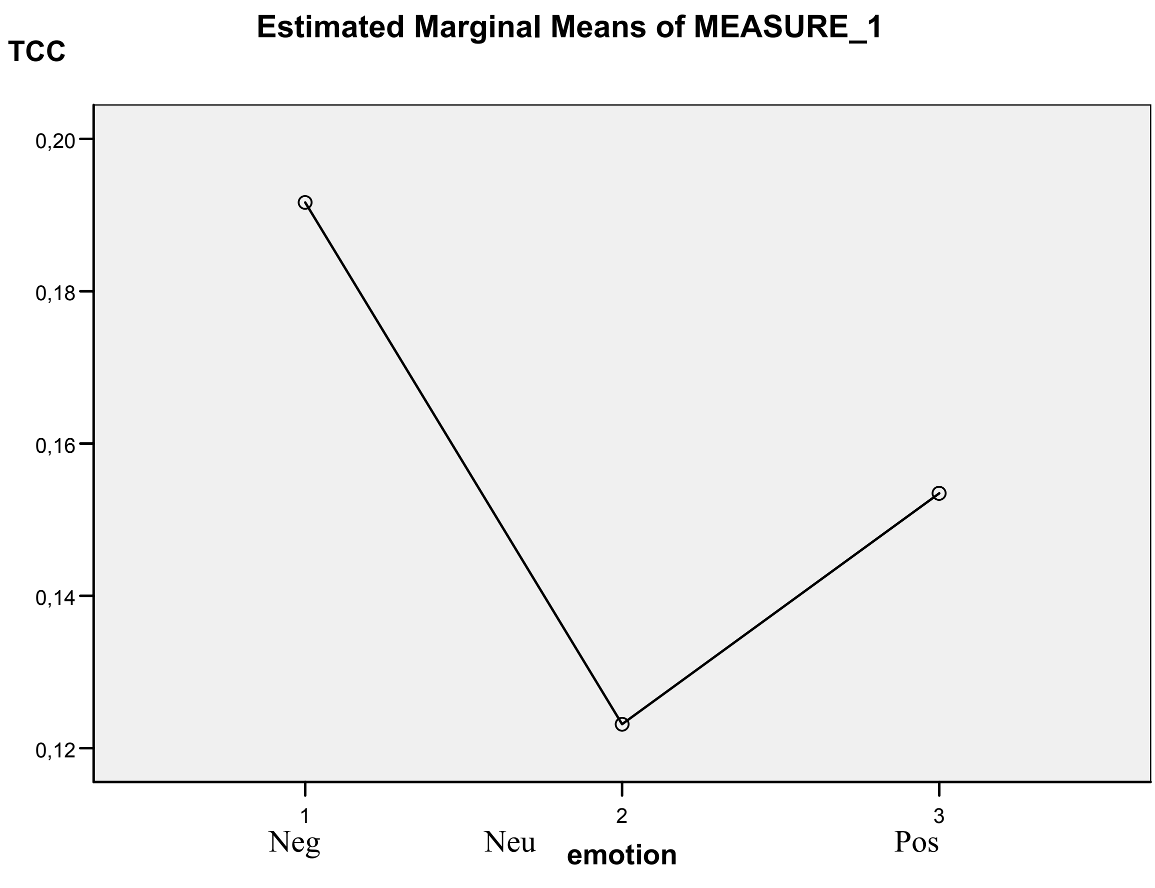


**Figure 11.** TCC in regard to negative, neutral and positive stimuli.

# Discussion

The main hypothesis of this study was that facilitated episodic memory leads to a decrease in memory mistakes especially for negative faces. In order to test the idea episodic memory had to be measured. The present study measured episodic memory with the help of a source memory test, employing a colour task.

The following results were obtained. Emotional arousal matters but no significant difference in regard to positive or negative facial expressions was found in regard to participants' discrimination accuracy. On the other hand, there is a significant difference between neutral faces and positive/negative faces. The second result is that there is a significant interaction between task and emotion that leads to a conclusion that response bias depends on the task that participants perform. The next result is that participants show a more liberal response bias for negative faces in a colour block in comparison to black-and-white block.

Subsidiary analyses on participants' source memory performance show no effect for emotion.

A final analysis indicates that temporal contextual confusion increases in particular for negative faces and this contradicts with the main hypothesis of this study.

The obtained results can be related to the theoretical background that was described in the introduction. The first result that touches upon arousal with emotional faces being remembered better in comparison to neutral ones can be explained by the amygdala's influence on memory mechanisms in the hippocampus. The role of the amygdala was emphasized in regard to patients with amygdala lesions, showing that these patients have impairments when it comes to emotional material. Thus, amygdala's role is said to be of outer importance, because amygdala is necessary for enhancing of emotional memories.

Due to most neurocognitive models the medial temporal region and specifically the hippocampus are crucial for episodic memory in its turn. The hippocampus is said to bind together "various attributes constituting the event" (Johansson, Mecklinger & Treese, 2004, 1847). This is very important for later retrieval.

The result that shows increased TCC for negative faces indicates that participants make more mistakes when it comes to negative stimuli. The latter fact shows that emotion has also negative effects on memory. It can be explained that amygdala actually influences control functions in the prefrontal cortex so that control processes do not function in the way they should. This influence can be due to the fact that amygdala functions develop and mature much earlier than functions in the prefrontal cortex.

As far as a more liberal response bias for negative faces in a colour block is concerned, the result corresponds to a very high extent with the results that were obtained in the event-related potential study on recognition memory for emotional and neutral faces (Johansson, Mecklinger & Treese, 2004). It could be due to the flexible criteria setting that was touched upon in the introduction.

The results obtained from source memory performance in regard to participants' accuracy and response bias correlate to a high extent with the results obtained from the previous analyses. These results indicate increase in regard to overall TCC for positive, negative and neutral faces in a colour as compared to a black-and-white block.

There are some other explanations available why the following results have been achieved and what could have been done better. One possible explanation can be that results may depend on the so-called attention grabbing effect. In regard to this study it can mean that participants focused on the main facial characteristics and left out such details as in what colour these characteristics have been presented. It could probably lead to a worsened source memory. The attention-grabbing effect can be related to a weapon-focus effect and the Easterbrook hypothesis that were described by Reisberg and Hertel (2004).

Another explanation can be that material was not thematically induced. It was visually induced. Only a few participants mentioned that they were really motivated to take part in the experiment as well as interested in obtaining their results after the experiment. The majority of participants admitted that the experiment took extremely long time. It could probably negatively affect ecological validity of the experiment.

As far as the external validity is concerned that deals with the ability of the study's results to generalize, it should be mentioned that the experiment has not produced the results in regard to main hypothesis and some further research is obviously needed. Absence of facilitated episodic memory for negative faces in the present study indicates that future studies should take into consideration some problems the present study possesses.

One of the complexities of the present study was that the constructed source memory test was very hard. The results showed very low performance in a colour task. The results obtained from a black-and-white block were actually good. The idea was to find a connection between TCC and the ability to source memory. However, no improved source memory performance for negative stimuli was found. In other words, no effect of emotion was found. One of the possible suggestions for future studies may be a suggestion to simplify the task, probably by minimizing the number of faces in a colour block because it was exactly the colour block that participants experienced as difficult. There were many participants who complained that there were a lot of aspects to control simultaneously and that it took a lot of time to perform the task.

Another suggestion is to question the usage of different colours because they were experienced differently by the subjects. Some participants admitted that red colour was associated with emotional stimuli. In contrast, green or blue colours were associated with a more neutral stimulus. It could probably affect participants' responses in a way that they mixed whether it was an “old” stimulus or a “new” one, and it could lead to a greater confusion.

Another aspect touches upon the programming of the experimental task. It would be useful to program the future experimental task so that the subjects can see if their responses have been registered or not. In the present study there were a lot of misses, when participants “jumped over” some faces because they concentrated on the remembering processing, or because they did not press the key hard enough. However, it could not have affected the results greatly because the extent of such misses was not high.

One more suggestion can be to better control whether participants participated in similar experiments earlier because one of the participants did the black-and-white block some time ago and it could probably worsen her results in particular.

As far as the complaints of some participants about that they had to press different keys during different stages in the experiment, it should be taken with caution. Participants complained that they felt themselves distracted because of this but it was one part of counterbalancing that controlled whether participants actually read the instructions before every new part in the experiment and were active, or whether they performed automatically without paying attention to alterations and were passive.

# Conclusion

The final result does not support the main hypothesis of this study as participants’ performance becomes even worse with the introduction of additional colours. This is not strange as a source memory test is obviously more complex than an easy recognition test. No facilitated episodic memory for negative stimuli as it is presented in this study has been observed. Thus, a conclusive test of the main experimental hypothesis awaits future research.

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