LUNDS UNIVERSITET

INSTITUTIONEN FÖR PSYKOLOGI

Emotion and Memory - The protective functions of semantic knowledge on memory errors

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Kandidatuppsats ht 2007

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Abstract

The present study aimed to investigate if celebrity (knowledge/semantic memory) can have protective functions against memory errors. We examined if famous faces, based on an interaction of semantic and episodic memory can lead to a deeper encoding, and if attractive faces, based on familiarity can lead to more confusion. Participants' ability to distinguish between studied and nonstudied faces in the test phase was measured using a continuous recognition test. As predicted, the analysis of old-new discrimination confirmed a deeper encoding for famous faces, and a more accurate recollection of these faces, compared to unfamous faces. Moreover, temporal context confusion increased for unfamous faces, in contrast to famous faces, which indicated that participants made more memory errors for unfamous faces. No effect involving attractiveness was found in the analyses of old-new discrimination and temporal context confusion. Taken together, the findings of the present study fail to support the idea that familiarity may be induced by the positive emotion conveyed by attractive faces and that this leads to greater memory confusion. However, they do support the proposal that prior knowledge improves episodic memory and may protect against memory confusion.

Emotion and Memory
- The protective functions of semantic knowledge on memory errors

How emotions are learned and remembered has become a subject of considerable interest in cognitive neuroscience. Emotional memory is considered a complex process involving multiple brain regions engaged at different phases of information processing: encoding, consolidation, storage and retrieval. The contributions of the amygdala, prefrontal cortex (PFC), and medial temporal lobe (MTL) memory system has been investigated considering these stages, with implications for understanding the underlying processes in recognition memory (see LaBar & Cabeza, 2006, for a review).

Although it is generally acknowledged that emotional memories tend to be quiet vivid and detailed, a significant body of research has demonstrated that memory may also be impaired by emotion, that is, emotional events are remembered accurately but incompletely. Evidence based on animal studies has shown that emotional arousal produces a memory-narrowing pattern. “The Easterbrook hypothesis” implies that arousal improves the focusing of attention to information at the center of an event, but disrupts attention to an event’s periphery and causes a disadvantage in remembering the event’s periphery. A comparative fact is the pattern known as the “weapon focusing effect”. This suggests that eyewitnesses to crimes often have a good memory for the criminal’s weapon (the central gist) but remember little else about the crime or the periphery (Reisberg & Hertel, 2004).

The amygdala is an important mediator of emotional influences on perception, and is a brain region responsible for emotional learning. The amygdala and hippocampus are located in the medial temporal lobe. Psychological evidence that emotion influences episodic memory have demonstrated that amygdala mediates the influences on memory through hippocampal activity and via interaction with prefrontal cortex and additional cortical areas (Dolan, 2002).

Studies of amygdala-lesioned patients have provided a foundation for understanding emotional memory. Research on patients with amygdala lesions has led to the view that arousal rather than valence is the crucial factor in engaging the amygdala during emotional memory performance (Winston et al., 2007; LaBar & Cabeza, 2006). These patients remember words that are emotionally valent but low in arousal in comparison to neutral ones, as well as neutral words encoded in emotional context relative to neutral contexts. Moreover, the patients do not focus on central items when memory is tested for audiovisual narratives that describe emotionally arousing events. Studies on patients with Urbach-Wiethe disease, with selective bilateral amygdala pathology, show deficits in long-term recall, or recognition of emotional material, such as words, pictures and stories (LaBar & Cabeza, 2006).

Confabulation is a memory disorder often associated with orbitofrontal damage or disconnection, particularly in the ventromedial prefrontal cortex. The orbitofrontal cortex is located in the prefrontal cortex, which interacts with the amygdala. Patients with lesions in these areas produce (often during autobiographical recollection) statements or beliefs of untrue stories, that involves unintentional distortions of memory. Confabulation is considered to be associated with impairments of memory control processes which are responsible for specification of retrieval cues and the maintenance of recollected information (Schnider, 2003). Furthermore, spontaneous confabulators tend to have a loss of temporal context in memory; as a result they fail to recognize the temporal order of stored information which leads to an inability to to judge the current relevance of memory information and a production of false memories (Schnider, Däniken, &, Gutbrod, 1996). This so called temporal context confusion (TCC) may be comparable to memory errors observed in studies of memory for emotional stimuli in healthy subjects, which will be discussed below.

The concept of episodic memory system has been characterized as personally experienced events, while semantic memory has been referred to general facts. Episodic and semantic memories have further been described in terms of different forms of consciousness, which is considered as the major distinguishing characteristic between the two concepts (e.g. Tulving, 2002). Episodic memory has been related to a “self-knowing” consciousness, which allows a person to have a sense of a personal self and a subjective experience through time of that self. Semantic memory, on the other hand has been associated with a “knowing” consciousness, which enables us to be conscious about knowledge that we possesses or think about.

Some concepts considered as “purely” semantic might involve an episodic part if they are relevant to ones personal experience. It is described by the term, autobiographical significance, which refers to a semantic concept with specific personal memories. The two aspects, semantic and autobiographical, although independent, do support each other. The neuropsychological studies of semantic dementia (SD) and Alzheimer’s disease (AD) has established that the semantic and autobiographical aspects of famous people knowledge relies on different brain regions or neural mechanisms, with the episodic component being depending on the hippocampal region whereas the semantic knowledge is supported by neocortex (Denkova, Botzung & Manning, 2006). Moreover, interactions between prefrontal cortex and medial temporal lobe areas have been observed during retrieval for autobiographical memories, public event information, and general knowledge. Activation has been found between different regions within the medial temporal lobe for autobiographical recollection but not with semantic concepts (see Simons & Spiers, 2003, for a review; Denkova, Botzung, Manning, 2006). Westmacott and Moscovitch (2003) examine the effects of autobiographical significance on semantic memory in an episodic recognition task. They reported that celebrities that were associated with events in participants own lives improved memory, compared to celebrities without any self-relevancy.

In the present study, we measured recognition performance; the ability to distinguish between previously studied and non-studied items. In studies of recall, a general improvement of memory for emotional stimuli has been observed. This so called “emotion-induced enhancement effect” implies that subjects recall emotional items better than neutral items (LaBar & Cabeza, 2006). In contrast, studies of recognition performance have demonstrated that emotional stimuli can induce an “emotion-induced recognition bias” indicating that subjects are more likely to respond “old” to a negative item compared to an emotionally neutral item, irrespective of the item’s old-new status. Consequently, this bias leads to enhanced hit rates and false alarm rates. Windmann and Kutas (2001) suggested that that prefrontal cortex may be responsible for relaxing the criterion for negative stimuli in order to ensure that emotional events are not missed or forgotten. An event-related potential study reported a more liberal response bias for both emotionally negative and positive faces compared to neutral faces, suggesting that criterion setting is relaxed by emotional arousal and not only by negative valence. Moreover, they reported facilitated episodic memory for emotionally negative faces compared to neutral and positive faces, and suggested that positive and neutral faces are based on a feeling of familiarity, while negative faces are based on recollection (Johansson, Mecklinger, & Treese, 2004). Such a proposal would be consistent with the idea that recollection leads to a decrease in false alarm rates, and might protect against memory errors, which will be discussed below.

A variety of “dual-process” models has proposed that recognition is based on two forms of memory processes: it may be based on “an acontextual sense of familiarity” (Rugg & Yonelinas, 2003, p. 313) or on recollection, depending on a relatively slower and more conscious process of episodic retrieval of detailed contextual information about previous events (see Rugg & Yonelinas, 2003, for a review). In addition, a distinction between the two processes has been made by studying patients with prefrontal cortex damage that have provided the idea that the prefrontal cortex, particularly hippocampus activity is crucial for recollection but less important for familiarity-based memory (see Simons & Spiers, 2003, for a review). Taking the two types of memory processes into account, they reveal different results in recognition memory tests, the hit rate (correct responses) is to a greater extent affected by recollection, and familiarity is often coupled with an increase in false alarm rate.

In the present study, we used repeated runs of a continuous recognition memory task to investigate to what extent temporal context confusion (TCC) is induced in normal healthy participants using a socially relevant stimulus material, namely faces. Participants are in a first run presented with a series of stimuli and asked to use two response alternatives to indicate first time presentations (“new”) and repetitions (“old”), see Figure 1 for an outline of response and item status combinations. The same instructions hold for the following run in which the same stimuli are presented in a different order. Temporal context confusion is seen when participants fail to reject stimuli that are familiar from the first run but presented for the first time in the second run (distracters). Thus, TCC reflects the inability to accurately assess the current relevance of information in memory (cf. Schnider et al., 1996).

The main idea was to examine if temporal context confusion increases as a function of emotion (attractiveness), and decreases as a function of semantic knowledge about the studied item (celebrity).

		Response	
		"Old"	**"New"**
Item status	**Old**	Hit	Miss
	New	False alarm	Correct rejection

Figure 1. The old-new recognition matrix

We used attractive and non-attractive stimuli faces, to test the effect of pleasantness, as a positive emotion linked to familiarity. Familiarity, repeated contact with or mere exposure to someone usually increases our liking for that person and it may make that person seem more attractive. Additionally, diverse observers agree in their perceptions of beauty much more than they disagree. A cross-cultural agreement about attraction does exist; Rhodes (2006) indicates that this may have evolved through sexual selection, she proposed three factors for biologically based preferences: the preference for an average face, i.e., proximity to a mathematically average trait of values in a face for a population. A second factor is the preference for bilateral facial symmetry. The last preference is sexual dimorphism (preference for masculinity or femininity), which signals reproductive potential and immune-competence.

A beautiful face triggers a positive evaluation the moment we see it (Cheng, Ferguson, & Chartrand, 2003) and we make this judgment automatically, without any conscious thought. The most fundamental assumption about attraction is that we get attracted to others whose presence is rewarding us, thus, attractive faces activate reward centers in the brain. The exact patterns of brain activation involved are somewhat varying across studies, typically reward- and emotion-related regions such as the orbitofrontal cortex, basal ganglia, and amygdala have been shown to be responsive to facial attractiveness (Werheid, Schacht, & Sommer, 2007).

Evolutionary advantage made it possible for us to quickly encode the attractiveness of a face. Familiarity communicated by positive facial expression can be misattributed to memory, and we therefore expect to observe an effect of attractiveness on familiarity as reflected in increased levels of memory confusion (i.e., TCC).

Additionally, we used faces of celebrities as stimulus material, since they are a part of our semantic memory and general knowledge. Semantic knowledge about celebrities has been closely related to recollection, as it bring to mind detailed contextual information about previous events. Furthermore, Stenberg, Hellman & Johansson (2007) proposed that knowledge about a stimulus domain enhances memory accuracy. One example is a recent study, where wine-experts showed improved recognition memory for wine-relevantly odorants (Parr, White, & Heatherbell, 2004). A face of a celebrity can be associated with known facts about the person, as the person's achievements, public appearance, etc., as well as episodic knowledge on bases of personal relevance such as seeing the face on the news. Stenberg, Hellman, and Johansson (2007) investigated the interaction between two types of semantic memory, and episodic memory. Taking pre-experimental knowledge into account, they showed that names of celebrities were better remembered than nonfamous high-frequency names. These results demonstrate that "celebrity", as a specific type of semantic knowledge supports episodic memory, and is based on recollection, while "frequency" as a non-specific type of semantic memory is highly related to familiarity, and interferes with episodic memory. Since semantic knowledge and episodic memory interact and support each other, famous faces may improve memory performance due to a deeper encoding for these faces (cf. Stenberg, Hellman, & Johansson, 2007). Moreover, the influence of participants' knowledge about famous faces might mimic the effect that negative emotion has on memory. Negative emotion can have protective functions against memory confusion, and we thus expect that participants can use recollection in order to reject irrelevant memory traces (distracters).

Based on the research reviewed above it is of interest to investigate if celebrity (knowledge/semantic memory) can protect against memory errors. 1) We predict a deeper encoding for famous faces, based on the interaction of semantic and episodic memory. This deeper encoding will allow participants to more successfully reject distracters in the second run of the continuous recognition task. 2) We expect that there are quick effects of attractiveness on familiarity. Positive emotion that is communicated by attractive faces can be misattributed to familiarity memory, which leads to memory confusion as is reflected in higher levels of TCC.

Method

Participants

Thirty-two students were recruited from Lund University, of which 16 were male. Thirty participants reported Swedish as their native language; while 2 reported German and Russian but had lived in Sweden more than 5 years. The mean age of the participants was 24 years (*S.D.* = 3.7), with a range from 19 to 33. Participants were compensated with a lottery ticket and all subjects gave informed consent.

Materials

Stimuli were color photographs of the faces of 30 famous, attractive, 30 unfamous, attractive, 30 famous, unattractive, 30 unfamous, unattractive persons. The set of faces were selected from various sources: image databases on the internet, Elfgren-database (Elfgren et al., 2006), Collection of facial images: Faces94 (Spacek, 2007). Famous persons were celebrities known from the mass media (e.g. actors, royalties, politicians, TV hosts, news anchors, and sport athletes. 120 unique faces were rated in a pilot study, on celebrity and attractiveness by a separate group of subjects (n=20 of which 8 were male) who did not participate in the experiment. Celebrity and attractiveness was rated using a scale from 1 to 5 where 1: “not attractive/famous” and 5: highly attractive/famous. Thirty faces were selected for each stimuli category (see Table 1) by choosing faces at the high and low ends of the distribution of the ratings of celebrity (M= 2.5) and attractiveness (M= 2.1). The photographs were digitally edited using Adobe Photoshop, a white background was applied, all clothing was made non-visible and all photographs were of the same size.

Table 1. Sets of stimuli categories, with thirty faces in each category**.**

	Famous	Unfamous
Attractive	30	30
Unattractive	30	30

In order to counterbalance target status the faces were divided into two sets, A and B with 15 faces from each category. Sets of each category were matched according to gender, celebrity, and attractiveness, which are illustrated in Table 2.

Table 2. Sets of counterbalanced target status of the faces**.**

	Mean value of celebrity	Mean value of attractiveness
Famous-attractive Set A	4,3	3,5
Famous-attractive Set B	4,3	3,4
Unfamous-attractive Set A	1,5	2,8
Unfamous-attractive Set B	1,3	2,8
Famous-unattractive Set A	3,7	1,8
Famous-unattractive Set B	3,6	1,8
Unfamous-unattractive Set A	1,4	1,4
Unfamous-unattractive Set B	1,5	1,6

Procedure

Participants were tested in groups of 1-3 at a time. Testing took place in a quiet laboratory with computers for each participant, on which each keyboard was marked with new-old colored stickers. A written instruction was given in a paper form, and was repeated on the computer screen before each run participants were informed before the experiment that the experiment where investigating memory for faces. The session took thirty-five minutes.

The task comprised two runs of a continuous recognition test containing the same set of faces but arranged in different order in each run. 120 unique faces were presented in each run (30 per category). 60 of these faces were repeated twice as targets along the run (15 per category). Thus, every run included 120 “new” items (distracters) and 120 “old” items (30 “new” and “old” responses per category). The lag between the first and the second repetition was between 11 and 15 items.

Participants were instructed to use their left and right index fingers to respond “new” for every first presentation (distracter) and “old” for every second and third presentation (target) and to make their old-new judgments as quickly and accurately as possible. The “f” and “j” keys of the computer keyboard were used as “old” and “new” response options, respectively. Response hands were counterbalanced across participants.

After each run, participants were allowed to take a short break and to start the next run self-paced. They were asked to forget that all pictures had already been presented and to indicate repetitions only within the current run. Four additional faces were included as filler items at the beginning of each run. These faces were not used as targets or distracters in any run.

To counterbalance target status across runs, two lists were created that were matched according to gender, fame, and attractiveness. Participants were randomly assigned to the different lists.

Every trial began with a 1000 ms fixation cross on a computer screen that was followed by a 500ms white screen. Thereafter the face was presented for 2000ms, also followed by a white screen (500ms).

All pictures were presented at the centre of the screen with a white background and subtended 5° of visual angle horizontally and 7° vertically. The experiment was implemented with E-prime software (Psychology Software Tools, Pittsburgh, PA).

Results

Data of participants' recognition memory performance are summarized in Table 3. All statistical analysis was performed using SPSS 15.0, and significance level was set at $p <$ 0.05. The obtained data was analyzed using repeated measures analysis of variance (ANOVA) with two within-subject factors: Celebrity (famous, unfamous) and Attractiveness (attractive, unattractive). Additional analyses of discrimination accuracy (Pr) and temporal context confusion (TCC) were conducted in order to investigate gender differences; subject gender was included as a between-subjects factor.

Table 3. Temporal context confusion (TCC), discrimination accuracy (Pr), correct responses (Hits), false alarms (Fa) are reported as means, standard error of the means (SEM) are given in the parentheses.

Type	TCC	Pr1	Hits (run 1)	Hits (run2)	Fa (run1)	Fa (run2)
Famous attractive	.03 (.01)	.96 (.00)	.98 (.00)	.97 (.00)	.02 (.00)	.05 (.01)
Famous unattractive	.04 (.01)	.97 (.01)	.97 (.00)	.97 (.00)	.04 (.00)	.10.(.01)
Unfamous attractive	.05 (.01)	.93 (.01)	.97 (.00)	.97 (.00)	.03 (.00)	.07 (.01)
Unfamous unattractive	.07 (.01)	.94 (.01)	.98 (.00)	.97 (.00)	.03 (.01)	.08 (.01)

Discrimination accuracy (Pr= Hits-false alarms) was analyzed in run 1; ANOVA revealed a main effect of Celebrity: $F(1,31)= 36.849$, $p< .05$, $n^2 = .543$, this indicates a greater discrimination accuracy of old and new faces for famous faces (M= .96), compared to unfamous faces (M= .93) , as shown in Figure 2 .Participants' ability to accurately discriminate was not influenced by attractiveness, no significant main effect of attraction was found: $F(1,31)= 3.282$, *ns*., and there was no interaction effect: $F(1,31)= .164$, *ns*. Additionally, no significant gender differences was found: $F(1,30)= 3.335$, *ns*.

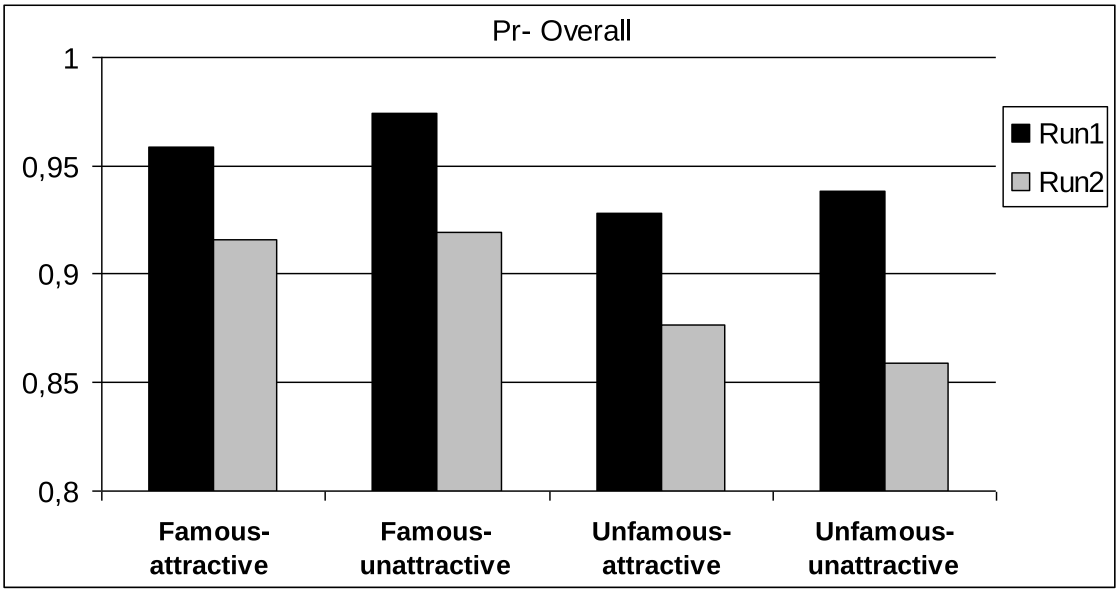

Figure 2. Overall discrimination performance **in the continuous recognition test, scores are calculated as:** Pr = Hits-false alarms

Temporal context confusion (TCC= FA2/Hit2- FA1/Hit1) is depicted in Figure 3 as a function of condition. One-sample t-tests demonstrated that reliable memory confusion was induced for all stimulus types (i.e., TCC measure greater than 0): famous, attractive: $t(31)= 3.20$, $p= .003$, famous unattractive: $t(31)= 3.63$, $p= .001$, unfamous attractive: $t(31)= 4.52$, $p= .000$, unfamous unattractive: $t(31)= 4.76$, $p= .000$. Figure 2 summarized the result demonstrating that TCC was greater for unfamous faces (M= .05), compared to famous faces (M= .03). Further analysis of TCC showed a significant main effect of Celebrity : $F(1,31)= 10.919$, $p<.05$, $n^2 =.260$, However, no significant main effect of Attractiveness, $F(1,31)= .563$, *ns*., nor an interaction between Celebrity and Attractiveness, $F(1,31)= .014$, *ns*., was found. Moreover, no significant gender difference in TCC was found, $F(1,30)= .363$, *ns*.

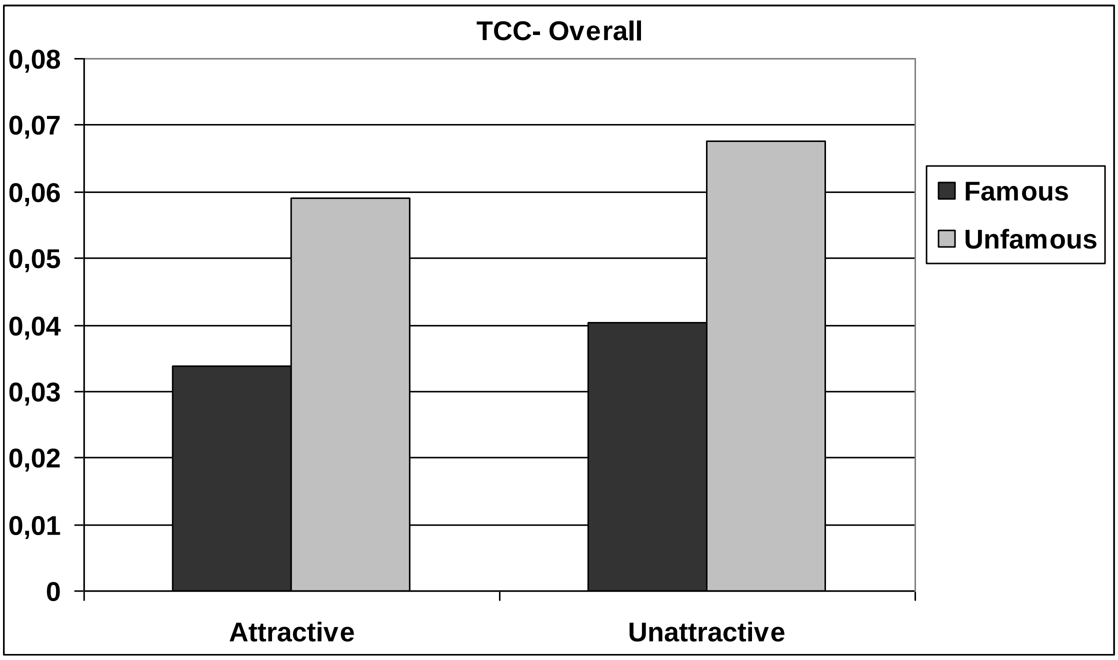

Figure 3. Overall temporal context confusion, scores are calculated as: TCC= FA2/Hit2-FA1/Hit1.

Discussion

The main hypothesis in this paper was that semantic knowledge/recollection may have protective functions against memory errors. We used a continuous recognition test containing the same set of faces but arranged in different order in each run. We expected a deeper encoding for famous faces, based on an interaction of semantic and episodic memory, and that positive emotion induces a feeling familiarity that would lead to greater memory confusion.

As predicted, the analysis of discrimination accuracy between old and new faces of the two factors, celebrity and attractiveness confirmed a deeper encoding for famous faces, and a more accurate recollection of these faces, compared to unfamous faces. Discrimination accuracy, on the other hand, did not show a difference between attractive and unattractive faces. Thus, participants' ability to discriminate between old and new faces was not influenced by the attractiveness of the faces.

An additional central finding of this study was that TCC decreased for famous faces relative to unfamous faces; while again no main effect of attractiveness was found. This indicates that participants make more mistakes for unfamous faces compared to famous faces and confirms the suggestion that famous faces can be recollected to a higher degree than unfamous faces and thus more successfully rejected.

Our result seems to confirm previous findings, where knowledge about the stimulus domain has been seen to lead to a recognition memory advantage (Parr, White, & Heatherbell, 2004; Stenberg, Hellman & Johansson, 2007). Participants have knowledge about celebrities; this may have increased recognition accuracy. In this respect, our finding confirmed earlier studies, where interaction between these two components has been proposed and are in parallel with the suggestion that "celebrity", as a type of semantic knowledge supports episodic memory, and is based on recollection.

The rhinal cortex have been characterized as a gate-keeper, responsible for judging the status of the stimulus, if the stimulus is interesting or novel enough it gets access to deepened encoding. On the other hand, if the item is of high familiarity, it usually gets denied. Stenberg, Hellman & Johansson (2007), showed that names of famous people interact with novelty, and that these both concepts affect encoding, thus well-known stimuli get encoded deeply. The semantic knowledge of a famous name or in this case of a famous face can be associated with detailed and unique events, as a result retrieval cues can be established and bind together at encoding. If the item is novel, the rhinal cortex gives access to the item and facilitates encoding (Stenberg, Hellman & Johansson, 2007)

Previous research has emphasized the crucial role of medial temporal lobe, and mainly the hippocampus for recollection (Dolan, 2002). The hippocampus is considered to provide different aspects of an episode to be linked over time, and to afterwards permit retrieval of the past event. The hippocampal system that includes the hippocampus, fornix, and the anterior thalamus is thought to underlie the process of recollection. A separate system that includes the perirhinal cortex is considered to support familiarity-based recognition of previous occurrence. The finding of facilitated memory for famous faces suggests that the efficacy of hippocampal binding mechanisms is enhanced due to an interaction between semantic and episodic memory, where prior knowledge causes a deeper encoding.

Previous memory research has demonstrated that emotional memory may be based on a context-free feeling of familiarity and coupled with an increase in memory-related errors such as the emotion-induced recognition bias or as we argue in TCC, where subjects tend to respond “old” to an item, even though the item is currently irrelevant and should be rejected as a distracter. We proposed that familiarity induced by the positive emotion characterizing attractive faces may lead to the similar memory confusion as reflected in a greater TCC for attractive as compared to unattractive faces. However, the results did not reveal such an effect of attractiveness on participants memory performance. To address this issue, one possible explanation have been proposed, Reisberg and Hertel (2004) made a distinction between thematically induced and visually induced emotional events and suggested that most laboratory studies are considering a type of emotion that are not representative in our day-to-day lives. Our emotional stimuli were visually induced; as a consequence the attractive faces may neither be representative nor typical for attraction as it naturally occurs outside laboratory.

In conclusion, we have demonstrated that famous faces gets deeper encoded, as the semantic knowledge of these faces supports and interacts with episodic memory. Consequently, famous faces were recollected to a greater extent than unfamous faces. Moreover, we expected that familiarity communicated by attractive faces can be misattributed to memory, and can lead to memory confusion. No support for this prediction was found, no difference between recognition performance for attractive and unattractive faces was obtained. Thus, the present study did not provide support for the idea that attractiveness increases temporal context confusion, but did demonstrate that semantic knowledge may decrease this particular type of memory errors.

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