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Directed Forgetting of Happy and Angry Faces: The Effects of Facial Emotion and Sex on Recognition Memory for Facial Identity

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by

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Abstract

The literature on directed forgetting – which refers to forgetting the specified information intentionally – has almost exclusively focused on either emotional words or pictures. Consequently, little is known about the impact of facial stimuli that demand more complex cognitive processing than words or pictures. A pilot study was conducted to obtain norm ratings on 152 facial images portraying neutral, happy and angry emotions. From this set of facial stimuli, 96 faces were selected for the main study. In the main study, 75 female participants were presented with 48 faces individually with equal number of happy and angry and, male and female faces. Half the faces were followed by a cue to remember and the remaining half a cue to forget. Following which, all participants were presented with emotionally neutral faces and asked to indicate if they had seen the face or not, including those they were previously told to forget. Results demonstrated that directed forgetting effects were significantly modulated by facial emotions and sex of faces. Specifically, forgetting costs (i.e., impaired memory for to-be-forgotten faces) were eliminated for angry faces and male faces. Given the literature that has documented happy face advantages in remembering (e.g., D'Argembeau, Van der Linden, Comblain, & Etienne, 2003), our findings suggest that forgetting of emotional faces may implicate potentially different mechanisms from those underlying remembering. The findings also imply the important role of emotional

expressions and sex of faces for adaptive memory: Among women, memory is enhanced for male angry faces because they signal threat or danger (Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007) and for female happy faces because they are associated with the notion of "tending and befriending" (Taylor et al., 2000).

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Chapter 1: Introduction

Until recent decades, the study of forgetting has been relatively neglected in the literature on memory. Investigating the forgetting phenomenon is important as forgetting information that is irrelevant or unimportant is functionally adaptive (Bjork, 2011). The ability to intentionally forget selected information has been studied empirically by using the directed forgetting (DF) paradigm. Within the paradigm, participants are presented with a series of items that are cued to either remember or forget during the study phase and their memory for all of the items is tested subsequently. The literature has consistently demonstrated forgetting costs, i.e., impaired memory for to-be-forgotten items relative to to-be-remembered items (for a review, see MacLeod, 1998).

Directed forgetting of emotional stimuli

A number of studies suggest that emotional material, compared to neutral material, is prioritized in memory processing (for a review, see Hamann, 2001). Given this, it is plausible to assume that emotional material will be resistant to forgetting. In favour of this view, the literature on directed forgetting has documented that emotional material undermines forgetting. For instance, previous studies demonstrated that emotionally charged pictures or words are more resistant to forgetting than neutral stimuli (Minnema & Knowlton, 2008; Nowicka, Marchewka, Jednoróg, Tacikowski, & Brechmann, 2011; Otani et al., 2012; Payne & Corrigan, 2007). Considered further, memory also differs between positive and negative emotional stimuli to some extent. At present, the literature on directed forgetting suggests that negative emotional stimuli are retained better in memory compared to positive emotional stimuli (Minnema & Knowlton, 2008; Otani, et al., 2012; Payne & Corrigan, 2007).

In this respect, the question that emerges is whether such resistance to forgetting can similarly be observed for other types of emotional material, such as faces, which are complex

and unique, requiring different cognitive processes compared to words and pictures. I consider this by referring to the literature on memory for emotional faces.

Memory for emotional faces

Relatively little is known about the influence of emotional faces on forgetting, while a wealth of studies has focused on the effect of emotional faces on remembering. On one hand, for instance, the happy face advantage over other emotional faces has been demonstrated in both recognition and attention (Craig, Becker, & Lipp, 2014; D'Argembeau, et al., 2003; Kirita & Endo, 1995; Patel, Girard, & Green, 2012; Shimamura, Ross, & Bennett, 2006). D'Argembeau et al. (2004, 2007) reasoned that the happy face advantage in recognition (i.e., facial identity) occurs because happy faces facilitate holistic processing associated with a broadened scope of attention, instead of feature-based local processing which involves a narrow focus. Thus, holistic processing leads to greater perceptual processing and elaboration, which in turn enhances subsequent recognition of happy faces. Their view is also consistent in part with findings that have shown faster and more accurate recognition for happy faces than those with negative emotional expressions (Calvo & Lang, 2005; Leppänen & Hietanen, 2003, 2004; Silvia, Allan, Beauchamp, Maschauer, & Workman, 2006). On the other hand, the angry face advantage was also documented in terms of attention capture. It was suggested that attentional bias toward angry faces is very robust not only at the bottom-up level (Frischen, Eastwood, & Smilek, 2008) but also top-down control (Huang, Chang, & Chen, 2011). Moreover, recent studies reported that angry expression facilitates the encoding and maintenance of facial identity in visual working memory but this effect is not evident for happy faces (Jackson, Linden, & Raymond, 2014; Jackson, Wu, Linden, & Raymond, 2009). It is noteworthy that the aforementioned literature on directed forgetting for non-facial stimuli appears to suggest that negative stimuli are more resistant to forgetting. Taking all into consideration, it remains unclear if subjecting emotional faces to the directed forgetting

procedure would lead to a memory enhancement of happy or angry faces. This is an important question that has not been adequately addressed in the literature. Given that forgetting of emotional stimuli may implicate mechanisms potentially different from those underlying remembering (Yang, Yang, & Park, 2013), it is important to study not only remembering but also forgetting of emotional faces to understand the representation strength of emotional faces in memory. Relatedly, there are evidence that suggest dissociable brain regions and cognitive processes in recognition between facial and non-facial stimuli (Bruce & Young, 1986; McCarthy, Puce, Gore, & Allison, 1997; Moscovitch, Winocur, & Behrmann, 1997). Moreover, in view of the happy face advantage in recognition memory as well as the angry face advantage in attention capture and visual working memory, it is important to understand what aspects of cognitive processing would be more relevant to forgetting. There is however, no evidence as yet on the effect of emotional faces on forgetting. Thus, the present study sought to examine these issues by employing the item-method DF procedure.

Research aims

My research aims are twofold. First, I aim to examine the effect of facial emotions on directed forgetting. Although the happy face advantage in recognition memory is well documented, I predict that angry faces may be more resistant to forgetting because angry faces compared to happy faces are relatively more effective in visual attention (Fox et al., 2000) and visual working memory (Jackson, et al., 2014). Moreover, from the evolutionary perspective, forgetting of angry faces may lead to negative consequences such as recurring or unresolved threats and danger or inadequate responses. Similarly, the threat detection advantage postulates that attentional resources are particularly tuned to angry and less so to happy faces (Feldmann-Wüstefeld, Schmidt-Daffy, & Schubö, 2011). Therefore, given (a) the advantage of angry face in attentional processing and (b) greater working memory resources underlying angry faces, I hypothesized that forgetting angry faces would be more

difficult than forgetting happy faces. This should be evidenced as attenuated forgetting costs (i.e., greater resistance to forgetting) for angry faces.

My second goal is to examine whether the sex of emotional faces would moderate directed forgetting. To have a more concrete and clear understanding of the relation between the sex of emotional faces and forgetting, I focused on female participants because of the following reasons. First, the literature has documented sex differences in women's superior sensitivity to emotional faces. For example, women, since infancy, are more sensitive to detecting facial emotions than men (Hall & Matsumoto, 2004; McClure, 2000). Women also exhibit superior remembering for emotional faces compared to men (Rehnman & Herlitz, 2007; Weirich, Hoffmann, Meißner, Heinz, & Bengner, 2011). Second, the literature has also shown the opposite-sex advantages in women's superior memory of emotional faces. That is, women are better at processing information relating to the opposite sex. For instance, women are generally more accurate in detecting happy and sad faces of men than those of women (Rahman, Wilson, & Abrahams, 2004). Women are also shown to react faster than men in learning information (e.g., names) associated with men's emotional faces (Hofmann, Suvak, & Litz, 2006). Given these, we hypothesized that the forgetting costs (i.e., greater resistance to forgetting) will be attenuated for male emotional faces, compared to female emotional faces.

Chapter 2: Pilot study

A pilot study is included in order to obtain ratings for emotional intensity (happy, anger), attractiveness and distinctiveness for male and female faces. A total of 152 happy and angry Asian faces were selected from three databases including the Asian Emotion Database (Wong & Cho, 2009; Wong & Cho, 2007), the Cohn Kanade Action Unit coded database (Kanade, Cohn, & Tian, 2000), and Matsumoto and Ekman's Japanese faces (Matsumoto & Ekman,

1988). Fifty-two were male happy faces, 48 male angry faces, 30 female happy faces and 22 female angry faces. These faces were cropped to show only faces without any extraneous information such as background or clothing details. Each image measures 340 × 300 pixels. Twenty-eight female undergraduates with a mean (SD) age of 21 (1.37) from the Singapore Management University participated in this rating task. They rated the faces for the degree of happiness and anger, the level of attractiveness, distinctiveness and arousal on a 7-point scale ranging from -3 (*not at all*) to +3 (*very much so*). In addition, the difference in emotionality between the emotional and neutral faces belonging to the same person was also obtained. The mean (SD) for the facial emotions, attractiveness and distinctiveness ratings are displayed in table 1.

[Insert Table 1 here]

Chapter 3: Main Study

Method

Participants. Seventy-five female undergraduate students participated in the study in exchange for either extra credit or monetary compensation ($5). Data from three participants were excluded from the analyses because they did not follow the instructions1.

Design. The type of memory cues (forget, remember), the sex of the faces (female, male) and facial emotions (happy, angry) were manipulated within participants.

Materials. Based on the pilot study, 48 faces were selected for the study phase with an equal number of male and female faces and, happy and angry faces. The emotionally neutral version of these faces and an additional 48 neutral faces were selected for the recognition test phase. The faces used in the study phase were further split into two sets,

matched for emotional intensity(see Table 2) and counterbalanced for those designated as either to-be-forgotten or to-be-remembered faces.

[Insert Table 2 here]

Procedure. Participants were comfortably seated in front of a computer screen measuring 15 inches diagonally at a distance of approximately 50 cm in front of them. The faces were presented randomly to the participants using the Direct RT software. Depending on the memory cue (remember, forget) followed immediately after the presentation of each face, participants were instructed to either remember or forget faces. A total of 48 faces were presented in the study phase. Half of them were followed by the remember cue and the rest followed by the forget cue. For each trial in the study phase, a face stimulus appeared for 3s, followed by a fixation point (+) for 1s. A memory cue (remember or forget) was presented for 3s followed by another fixation point for 1s prior to the next trial.

After the study phase, a 1-min filler task was administered to reduce recency effects. In the task, participants were asked to write down numbers in descending order of threes from 157 (Goernert, Corenblum, & Otani, 2011; Minnema & Knowlton, 2008; Otani, et al., 2012). In the test phase, 96 faces were presented including 48 old faces from the study phase and another 48 new faces that were not presented during the study phase. Note that during the recognition test, all the test faces were presented with neutral expression, and participants responded to each neutral face by pressing either Old or New keys, regardless of the prior memory cue (remember or forget) associated with the face during the study phase. The response words “Old” and “New” remained on the screen, corresponding to the mouse click responses. There was no time limit for the recognition decisions although participants were asked to respond as fast and as accurately as possible. When the participants recognized the face, they were further asked to recall the facial emotion displayed by the face during the

study phase. Respond words, “Happy” and “Angry”, remained on the computer screen, the position of which corresponded to the mouse click responses.

Results

Only correct responses were included in the analyses. Reaction times faster than 250ms or longer than 3 standard deviations from the mean were removed. The correct recognition rate was submitted to a repeated-measures analysis of variance (ANOVA) with Memory cue (remember, forget), Sex of the face (male, female), and Facial emotion (happy, angry) as within-participant factors.

Recognition accuracy. Consistent with previous DF studies, we replicated directed forgetting for emotional faces (Fitzgerald, Price, & Oriet, 2013; Goernert, et al., 2011; Metzger, 2011; Paller, Bozic, Ranganath, Grabowecky, & Yamada, 1999). The main effect of Memory cue indicated that faces cued to remember (M = 0.51, SD = 0.02) were more frequently recognized than those cued to forget (M = 0.47, SD = 0.02), $F(1, 71) = 4.607$, $p = .035$, $\eta^2_p = .061$. We also found the main effect of Facial emotion, $F(1, 71) = 4.299$, $p = .042$, $\eta^2_p = .057$, indicating that angry faces were recognized (M = 0.51, SD = 0.02) more frequently than happy faces (M = 0.47, SD = 0.02). The effect of Sex of the face was not significant, $F(1, 71) = 0.518$, $p = .474$, $\eta^2_p = .007$.

Moreover, several interaction effects were observed. Most importantly, we found a significant interaction between Memory cue and Facial emotion, $F(1, 71) = 4.631$, $p = .035$, $\eta^2_p = .061$ (see figure 1a). Planned comparisons of paired t-tests revealed that forgetting costs (i.e., impaired recall of faces that were cued to forget) were observed for happy faces, $t(71) = 2.947$, $p < .01$, but not for angry faces, $t(71) = -0.043$, $p = .966$. This indicates that angry faces were resistant to forgetting while happy faces were not.

We also found a significant interaction between Sex of the face and Facial emotion, $F(1, 71) = 14.88$, $p < .001$, $\eta^2_p = .173$ (see figure 1c). Planned comparisons of paired sample *t*-tests showed that faces with happy emotion were recognized significantly more when displayed by women than men, $t(71) = -2.947$, $p < .01$. In contrast, angry emotion was recognized (marginally) better when displayed by men than women, $t(71) = 1.850$, $p = .068$. Last, a marginally significant interaction was observed between Sex of the face and Memory cue, $F(1, 71) = 3.571$, $p = .063$, $\eta^2_p = .048$ (see figure 1b). Planned comparisons of *t*-tests showed that forgetting costs were evident only for female faces, $t(71) = 2.870$, $p < .01$, but they were eliminated for male faces, $t(71) = 0.392$, $p = .696$. The rest of the effects were not significant.

Recall of facial emotion. For each face that was recognized as Old, participants were further asked to indicate the facial emotion (happy, angry) that had appeared during the previous study phase. Only faces whose facial emotions were correctly recalled were included in the analyses. Recall rates were submitted to a repeated measures ANOVA with Memory cue (remember, forget), Sex of the face (male, female), and Facial emotion (happy, angry) as within-participant factors. We found a significant interaction between Sex of the face and Facial emotion, $F(1, 50) = 8.160$, $p < .01$, $\eta^2_p = .140$ (see figure 1d). Consistent with our findings above, planned comparisons of *t*-tests showed that participants recalled better when happiness appeared on women's faces than on men's faces, $t(69) = -3.993$, $p < .01$. In contrast, an opposite pattern was observed for angry faces such that participants recalled better when anger appeared on men's faces than on women's faces, $t(69) = 2.070$, $p = .042$. The rest of the effects were not significant.

[Insert Figure 1 here]

Discussion

Using the item-method directed forgetting procedure, the current study demonstrated that the directed forgetting effect was moderated by emotional faces; angry faces were resistant to forgetting, while happy faces were not. Our results are in line with previous research that has shown attenuated forgetting costs for negative valent pictures and words (Minnema & Knowlton, 2008; Otani, et al., 2012). Our study demonstrated that the angry face advantage hindered forgetting while the happy face advantage in facial identity did not lead to a greater resistance to forgetting. Although happy faces are shown to enhance remembering (D'Argembeau & Van der Linden, 2007; D'Argembeau, et al., 2003), they are subjected to typical forgetting costs. This suggests that forgetting of emotional faces may implicate mechanisms that are potentially different from those which underlie remembering of emotional faces.

It is important to consider why the happy face advantage in remembering did not lead to a reduction in forgetting costs, while the angry face advantage did. The literature suggests that happy faces convey information such as trustworthiness which signals an absence of threats or problems (Schwarz & Clore, 2007; Todorov, 2008). By contrast, angry faces signal the presence of threats, dangers, or problems in the context, which requires an immediate attention and action. Therefore, in view of the survival value associated with these emotional faces, forgetting of happy faces may not necessarily involve any harmful consequences, while forgetting of angry faces may be maladaptive because it leads people to ignore threats or, delay or avoid a desirable resolution to the problems. Reportedly, our attentional resources are particularly tuned to angry or other negative (sad) faces (Feldmann-Wüstefeld, et al., 2011). This is particularly relevant to females, including both children and adult, who are more prone to show bias towards emotionally negative pictures, as demonstrated by increased physiological reactance (Bradley, Codispoti, Sabatinelli, & Lang, 2001; McManis, Bradley, Berg, Cuthbert, & Lang, 2001) and left amygdala activation (Stevens & Hamann, 2012).

Together, because of negative consequences implicated in the forgetting of angry faces and women's sensitivity towards negative stimuli, it is plausible that angry faces are likely to draw greater attention in the first place and lead to better encoding and maintenance in memory. This explains why angry faces attenuate forgetting costs while happy faces do not.

Notably, forgetting costs were also eliminated for male faces, but not for female faces (see Fig. 1b). Regardless of the memory cue (remember, forget), female participants showed equivalent recognition rates for male faces, suggesting that memory for male faces was strong and not affected by the memory cue. This finding is consistent with previous studies that have demonstrated the opposite-sex advantage in processing faces such that females are more efficient in processing male than female faces (Hofmann, et al., 2006; Rahman, et al., 2004). Given this, female participants readily attended to male faces and remember information such as names associated with male faces (Hofmann, et al., 2006). Such enhanced attentional processing of male faces is likely to improve encoding and subsequent retrieval processes, both of which are believed to attenuate forgetting costs. Moreover, memory for male faces was further moderated by the type of emotional expression. In particular, our female participants recognized male angry faces more frequently than female angry faces. Male happy faces, however, were recognized less frequently than female happy faces. These findings are consistent with the view that women are particularly sensitive to facial emotion that signals threats or dangers because women are comparatively more vulnerable than men in terms of physical size and strength (Becker, et al., 2007; Geary, 1998). Thus, women may have increased demand for male angry faces to be remembered compared to female angry faces. Alternatively, remembering female happy faces may be particularly important compared to male happy faces. Because women are associated with the notion of "tending and befriending" (Taylor, et al., 2000), forming affiliation with other females who show positive expression should reduce perceived vulnerability (Taylor, et al., 2000). Thus

remembering female happy face confers adaptive benefits. Further, the current findings is also consistent with the sex stereotypic emotion hypothesis where angry faces are typically associated with men whereas happy faces are associated with women (Brody & Hall, 2000; Fischer, 1993). It was also shown that detecting male angry faces and female happy faces was faster than detecting male happy faces and female angry faces respectively (Becker, et al., 2007). Our findings on recall performance (see Fig. 1d) also provide support for this view. When the participants recalled the emotion for the face they saw during the study phase, they were more accurate for male angry faces and female happy faces, compared to their respective counterparts.

It is also important to consider the putative mechanisms underlying the effects of sex and facial emotion on directed forgetting based on the extant literature. Of particular relevance to the current item-method directed forgetting procedure for faces, attentional processes may be geared towards certain facial emotions or sex. Although Dimberg, Thunberg and Elmehed (2000) did not observe a difference in the degree of facial muscles activation towards perceived happy and angry faces that would suggest the involvement of preattentive processes, they contend that preattentive processing of happy faces may be confounded by mimicry where seeing a happy face automatically leads to the mimicry of smiling. As such, attentional processing may be amenable to emotionally negative stimuli such as angry faces following encoding or enhanced during selective rehearsal (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Ohman, Flykt, & Esteves, 2001).

Our study extends the literature on directed forgetting by demonstrating that forgetting costs are moderated by emotional expressions on faces and the sex of the faces. This finding is relevant to research which seeks to investigate the implications of forgetting on subsequent behaviors. For instance, considering that the directed forgetting effect for non-facial negative valent stimuli is attenuated among individuals with depression (Power,

Dalgleish, Claudio, Tata, & Kentish, 2000) and other negative mood (Minnema & Knowlton, 2008; Myers & Derakshan, 2004), it would be worthwhile to examine if the directed forgetting effect is likewise attenuated for facial stimuli. Specifically, subsequent approach and avoidant behavior could be examined in association with their ability to forget faces with negative compared to positive expressions.

To conclude, the findings are in line with the notion of adaptive memory in recognizing facial identity suggesting that adaptive remembering and forgetting may involve drawing on features including emotion and sex to determine which individuals are important in the future. Considering that adaptive memory involves evolved memory systems that retain essential survival and reproductive fitness related information (Nairne, Thompson, & Pandeirada, 2007), the present study provides the first evidence consistent with the adaptive advantage conferred by attenuating the forgetting effect for certain faces.

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Footnotes

[1] One participant did not understand the instructions on memory cue, one recorded down details of the faces she saw during the study phase and another identified all faces as ‘old’ during the recognition test. The inclusion of these three participants did not alter the significance of the results other than slightly attenuating the interaction effects and slightly augmenting the main effects.

Tables

Table 1. Means and standard deviations for the male and female, happy and angry faces for ratings provided by 28 female participants.

	Degree of happiness	*Degree of anger*	*Attractiveness*	*Distinctiveness*	*Arousal*
Male happy	3.76 (0.69)	1.48 (0.55)	3.00 (1.00)	2.73 (0.72)	3.48 (1.04)
Male angry	1.96 (0.72)	3.01 (1.24)	2.19 (0.89)	2.70 (0.66)	3.60 (1.03)
Female happy	3.92 (0.63)	1.45 (0.59)	3.33 (0.79)	2.76 (0.77)	3.23 (0.94)
Female angry	1.83 (0.74)	3.29 (1.28)	2.36 (0.90)	2.72 (0.63)	3.24 (1.12)

Table 2. Mean ratings of emotional intensity for emotional faces as a function of the set, facial emotions, and sex of the faces.

	Male						**Female**					
	Happy			Angry			Happy			Angry		
	Set A	Set B	*t*	Set A	Set B	*t*	Set A	Set B	*t*	Set A	Set B	*t*
Degree of happiness	3.63 (0.63)	3.61 (0.58)	0.33	1.67 (0.49)	1.63 (0.47)	0.43	3.68 (0.47)	3.67 (0.56)	0.16	1.59 (0.39)	1.75 (0.51)	-1.98
Degree of anger	1.57 (0.53)	1.41 (0.33)	2.43	3.57 (0.74)	3.41 (0.70)	1.78	1.40 (0.35)	1.52 (0.33)	-2.10	3.52 (0.76)	3.48 (0.80)	0.37

Note. Standard deviations are shown in parentheses. $p < .01$.

Figure

Figure 1. (a) shows the proportion of faces recognized as a function of facial emotion and memory cue, (b) shows the proportion of faces recognized as a function of the sex of the face and memory cue, (c) shows the proportion of recognition of faces as a function of facial emotion and the sex of facial stimuli, (d) shows proportion of recall of the facial emotion as a function of facial emotion and the sex of facial stimuli. Error bars represent the standard error.