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Chapter 11

AGING AND SHORT-TERM MEMORY FOR FACE IDENTITY OF EMOTIONAL FACES

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ABSTRACT

Age differences have been observed in emotional modulation of long-term memory (LTM) but have not yet been investigated in short-term memory (STM) in a comparable manner. In this study, age differences in the effect of stimulus emotionality on STM for stimulus content were examined. Younger (18-29 years) and older (61-77 years) adults completed a STM task with angry, happy, and neutral faces. Memory for face identity was increased for angry and neutral compared to happy faces. The response bias was most conservative for angry, and most liberal for happy faces. No age differences were observed in this emotional modulation of STM. It is argued that this is not due to lack of statistical power or to participant characteristics, but rather to the constraint nature of the task (probe-guided retrieval and short retention interval). The current findings do not suggest that emotional modulation of STM changes across the lifespan.

Keywords: Working memory; Emotion; Faces; Expressions; Aging.

INTRODUCTION

Many studies have examined age differences in emotional long-term memory (LTM), and age differences have been observed in several of these studies (see Mather & Carstensen, 2005, for a review). To our knowledge, only one study has investigated age differences in

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emotional short-term memory (STM). In that study, younger and older adults viewed unpleasant and pleasant pictures and were instructed to memorize the intensity of the feeling that a picture elicited. Older adults showed superior memory for pleasant versus unpleasant feelings, while younger adults showed the opposite pattern (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005). Findings in the LTM domain, however, typically concern memory for the emotional stimuli themselves, instead of memory for the elicited feelings. We performed the present study to examine age differences in STM for the content of emotional stimuli.

Both STM and LTM decline with aging, starting already in young adulthood (Park & Reuter-Lorenz, 2009). Recall memory, which is dependent on the process of recollection, declines more with age than recognition memory, for which the process of familiarity suffices (Light, Prull, La Voie, & Healy, 2000). Age may also influence the emotional modulation of memory (Mather & Carstensen, 2005). In general, it is assumed that people remember salient emotional information better than non-emotional information (Kensinger, 2004). Age differences in emotional processing would arise in the form of a so-called positivity effect, which is “a trend for adults to increasingly process positive information and/or decreasingly process negative information compared with other information with advancing age” (Langeslag & Van Strien, 2009, p. 376; Mather & Carstensen, 2005; but see Uttl & Graf, 2006). This positivity effect has been observed not only when comparing younger (approx. 18-30 yrs) with older adults (approx. 60-80 yrs), but also when comparing younger with middle-aged adults (approx. 40-55 yrs) (Charles, Mather, & Carstensen, 2003).

The goal of the present study was to examine age differences in STM for emotional stimulus content. In studies involving STM for face identity of emotional faces, younger adults had better memory for angry compared to happy and neutral faces (Jackson, Wolf, Johnston, Raymond, & Linden, 2008; Jackson, Wu, Linden, & Raymond, 2009). Memory for the identity of faces is important in both younger and older adults’ daily life. It is called upon in social interactions in which it is relevant to remember the identity of those individuals that reveal their judgement, mood, or intentions through their facial expressions. Here we used the emotional face STM paradigm of Jackson et al. (2008; 2009) to test age differences in STM for the content of the emotional stimuli (i.e. face identity), and not for the emotion conveyed (e.g. facial expression or feeling/emotion elicited).

For LTM, a previous study has demonstrated a positivity effect in memory for emotional faces. Younger adults recognized positive and negative faces equally well and older adults recognized positive faces better than negative faces (Mather & Carstensen, 2003). In another LTM study, however, such positivity effect was not observed. Younger adults recognized negative faces best, neutral faces intermediately and positive faces least, whereas older adults recognized neutral faces better than positive faces (Grady, Hongwanishkul, Keightley, Lee, & Hasher, 2007). In three more LTM studies, age differences in the effect of facial expression on recognition memory were absent all together (D'Argembeau & Van der Linden, 2004; Leigland, Schulz, & Janowsky, 2004; Spaniol, Voss, & Grady, 2008). It is unclear why the findings of these LTM studies differ, but it may have to do with differences in the length of the delay between the study and test phases (which varied between 5 and 30 minutes), the specific facial expressions used, and the different recognition measures that were computed (discrimination indices or proportional scores (see also Uttl & Graf, 2006)).

The above mentioned findings concern the ability to distinguish faces that were or were not previously encountered, which is called discrimination. To fully consider recognition memory, a measure of response bias needs to be considered as well (Snodgrass & Corwin, 1988). The response bias reflects the tendency to classify a certain stimulus as previously encountered, irrespective of its actual old or new status. Generally, people adopt a more liberal response bias for emotional than neutral stimuli (Ochsner, 2000; Windmann & Kutas, 2001), yielding higher hit and false alarm rates for emotional than neutral stimuli. This more liberal response bias for emotional stimuli would ensure that information that is relevant for survival and/or reproduction is not missed or forgotten, and is thought to be mediated by the prefrontal cortex (Windmann & Kutas, 2001). In some LTM studies, age differences in emotional modulation of response bias were absent (Charles et al., 2003; Comblain, D'Argembeau, Van der Linden, & Aldenhoff, 2004; Spaniol et al., 2008), whereas in other studies age differences in emotional modulation of false alarm rate or response bias were observed that are consistent with the positivity effect (Fernandes, Ross, Wiegand, & Schryer, 2008; Kapucu, Rotello, Ready, & Seidl, 2008; Thapar & Rouder, 2009).

Based on previous studies regarding STM for the identity of emotional faces (Jackson et al., 2008; Jackson et al., 2009), we expected to find increased discrimination for angry faces in younger adults. With respect to the response bias, previous LTM studies (Ochsner, 2000; Windmann & Kutas, 2001) led to the hypothesis that the response bias would be more liberal for emotional than neutral faces. With respect to age differences in emotional STM, the hypotheses that positivity effects would occur in discrimination and/or response bias were put to the test. Such positivity effects would imply that older adults would have relatively better memory and/or a more liberal response bias for happy than angry faces compared to younger adults. However, because of previous conflicting results of LTM studies we were not sure whether to expect age differences in emotional modulation of discrimination and response bias in STM.

METHOD

Participants

Participants were 20 younger (mean age 20.7 years; age range 18-29 years; 10 men) and 20 older (mean age 68.9 years; age range 61-77 years; 10 men) adults who volunteered to take part. Participants were not depressed[1], reported to be in good neurological and psychiatric health and did not use centrally-active drugs. The older adults were not demented, as they had a Mini Mental State Exam (MMSE) score of at least 27 (Derix et al., 2003; Folstein, Folstein, & McHugh, 1975). Participants' education was scored on a scale ranging from 1 (primary education) to 8 (master degree) (De Bie, 1987). The younger participants ($M = 7.0$, $SD = 0.2$) tended to have completed more formal education than the older participants ($M = 6.2$, $SD = 1.7$), $F(1,38) = 3.8$, $p = .058$. Visual acuity, if necessary corrected with glasses or contact lenses, was assessed using a Landolt-C card. Although the younger participants ($M = 2.0$, $SD = 0.5$) had higher visual acuity than the older participants ($M = 1.3$, $SD = 0.4$), $F(1,38) = 27.5$, $p < .001$, all participants had a visual acuity of at least 0.8 and asserted

[1] Younger participants were considered non-depressed if they scored less than 13 on the Beck Depression Inventory (BDI) (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Lasa, Ayusi-Mateos, Vázquez-Barquero, Díez-Manrique, & Dowrick, 2000) and older adults if they scored less than 11 on the Geriatric Depression Scale (GDS) (Yesavage et al., 1983).

sufficient capability to view the faces. Participants were rewarded with course credit or money (at a rate of €7.50 per hour). The study was approved by the local ethics committee and the participants gave written informed consent prior to testing.

Stimuli and Memory Task

The stimuli for the STM task were 18 gray-scaled faces from the Ekman and Friesen (1976) series: six men each displaying angry, happy and neutral facial expressions (cf. Jackson et al., 2008; Jackson et al., 2009; Langeslag, Morgan, Jackson, Linden, & Van Strien, 2009). The faces subtended a visual angle of 2.7° vertically and 2.4° horizontally and were presented against a white background. A trial consisted of the following displays, see Figure 1. First, a black fixation cross that increased and decreased in size indicated the start of a trial. During the encoding phase, an array of four stimuli was presented for two seconds. These stimuli were one to four faces, resulting in a memory load of one to four, with scrambled faces occupying the locations not filled by faces. The stimuli were arranged in a two by two grid around a black fixation cross (0.4°) in the centre of the screen with the centre of each stimulus 1.8° away from the fixation cross. During the retention phase, a fixation cross was presented for one second. During the retrieval phase, a probe face occurred in the centre of the screen. The participants had to decide whether or not the probe face matched one of the faces in the preceding encoding array (50% match trials). The response terminated the retrieval phase, and initiated the next trial.

It is important to note that this STM task (Jackson et al., 2008; Jackson et al., 2009) was an identity matching task, and not an emotion matching task. Because faces of only six individuals (each displaying all three expressions) were used, each face was repeated multiple times during the experiment. This actually ensured that the task tapped into STM and not into LTM, because participants had to decide whether a probe face, even though it may have been present in LTM storage because of its appearance on previous trials, matched any of the encoding faces in the current trial only. Furthermore, all of the faces within one trial displayed the same facial expression. This made facial expression uninformative for the task and prevented the occurrence of attentional biases towards or away from faces with certain expressions during encoding. This design allowed the investigation of age differences in the influence of expression on STM without the potentially confounding influence of age differences in attentional biases (Isaacowitz, Wadlinger, Goren, & Wilson, 2006a; Isaacowitz, Wadlinger, Goren, & Wilson, 2006b; Mather & Carstensen, 2003) during encoding.

Procedure

Upon arrival in the lab, the participants completed the above mentioned screening procedures. Following, the participants were introduced to the memory task and were told that the scrambled faces and the facial expressions could be ignored because those would not be useful for the task at hand. Participants were instructed to respond to the probe face by pressing the ‘A’ (match) or the ‘L’ (mismatch) keys on a keyboard, with their left and right index fingers respectively, as accurately as possible. Participants were asked to try to maintain fixation at the fixation crosses at all times.

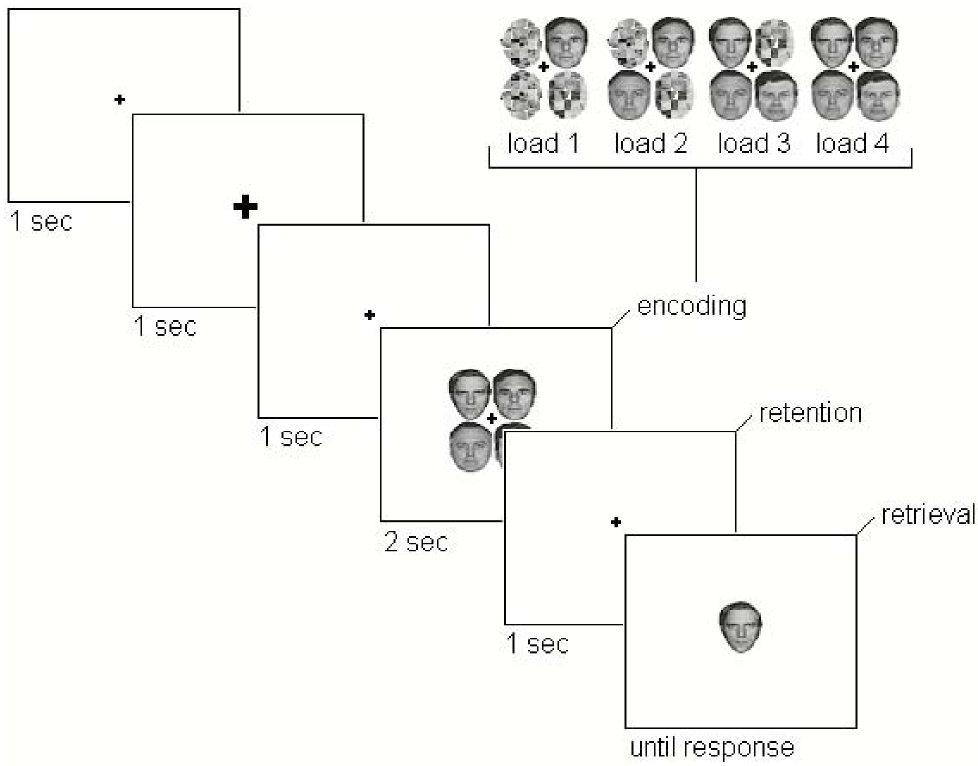

Figure 1. Trial overview

After some practice trials, the participants completed a total of 192 experimental trials: 3 facial expressions x 4 loads x 2 match/mismatch x 8 trials per condition. The order of the trials was random with respect to memory load, facial expression, face identity, location occupied, and match/mismatch. The task was divided into four blocks interleaved with short breaks. After the final block, the participants rated the valence and arousal they experienced when viewing each face with a computerized version of the Self-Assessment Manikin (SAM) (Lang, 1980).

Analyses

The hit rates (*H*, i.e. proportion correct 'match' responses) and false alarms rates (*FA*, i.e. proportion incorrect 'match' responses) were computed using the correction recommended by Snodgrass and Corwin (1988). Memory performance was represented by the discrimination index $Pr = H - FA$, where $Pr = 1$ reflects perfect performance and $Pr = 0$ reflects chance performance, and by the response bias index $Br = FA / (1 - Pr)$. The response bias index describes the tendency of participants to respond 'match' irrespective of the true match or mismatch status of the probe stimulus, where *Br* > 0.5 indicates a liberal response bias and *Br* < 0.5 indicates a conservative response bias (Snodgrass & Corwin, 1988)[2].

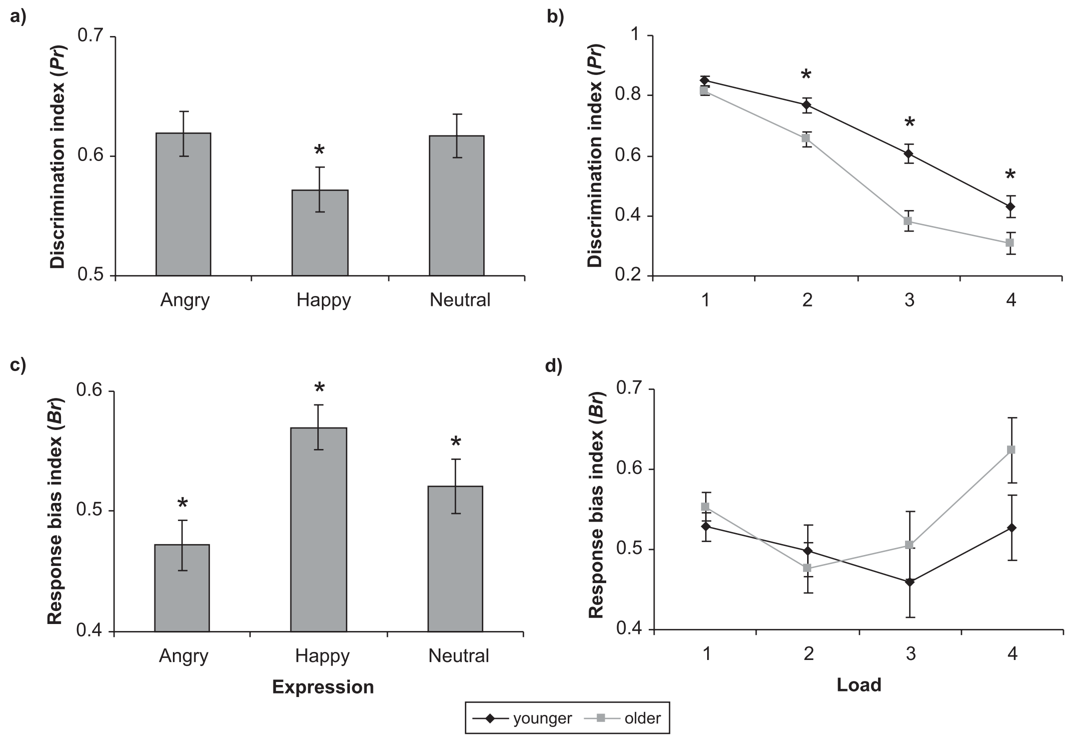

Figure 2. a) The discrimination index was lowest for happy faces, * both *p*s < .014 b) Older adults had a lower discrimination index than younger adults in loads 2 to 4, * all *p*s < .020 c) The response bias was most liberal for happy faces, intermediately liberal for neutral faces and least liberal for angry faces, * all *p*s < .023 d) No age differences occurred with respect to the response bias index

The data were analyzed with repeated measures analysis of variance (rmANOVA). Valence and arousal ratings were analyzed with the factors Expression (angry, happy, neutral), and Age group (younger, older). Memory performance measures *Pr* and *Br* were analyzed with factors Expression, Load (1, 2, 3, 4), and Age group. When applicable, degrees of freedom were corrected with the Greenhouse-Geisser correction. The *F* values, the uncorrected *df*s, the epsilon (ε) values and corrected probability levels are reported. A two-sided significance level of 5% was selected. Significant effects were followed-up by independent samples *t*-tests when testing age group effects and by paired samples *t*-tests when testing expression or load effects. In the case of load effects, consecutive loads were compared.

[2] When analyzing *d'* and *C*, as discrimination and bias indices respectively, the same pattern of results was obtained.

RESULTS

Valence and Arousal Ratings

Valence. There were a significant effect of Expression, $F(2,76) = 189.1$, $\varepsilon = .74$, $p < .001$, and a significant Expression x Age group interaction, $F(2,76) = 4.3$, $\varepsilon = .74$, $p = .028$. Both the younger and older participants associated angry faces with lowest valence (younger: $M = 3.1$, $SD = 0.8$, older: $M = 3.5$, $SD = 1.3$), neutral faces with intermediate valence (younger: $M = 4.7$, $SD = 0.5$, older: $M = 4.7$, $SD = 0.9$), and happy faces with highest valence (younger: $M = 7.4$, $SD = 0.8$, older: $M = 6.7$, $SD = 1.0$), all *p*s < .001. Yet, the older participants rated happy faces as less pleasant than the younger participants did, $p = .015$. There was no significant main effect of Age group, $F < 1$, *ns*.

Arousal. A significant effect of Expression, $F(2,76) = 19.3$, $\varepsilon = .98$, $p < .001$, and a significant Expression x Age group interaction, $F(2,76) = 7.9$, $\varepsilon = .98$, $p = .001$, were observed. The younger participants rated angry ($M = 5.4$, $SD = 1.3$) and happy faces ($M = 5.8$, $SD = 1.4$) as more arousing than the neutral faces ($M = 3.8$, $SD = 1.3$), both *p*s < .001. The arousal ratings for angry and happy faces were not significantly different, $p = .29$. The older participants rated happy faces as most arousing ($M = 5.3$, $SD = 0.8$), both *p*s < .003, and angry ($M = 4.1$, $SD = 1.1$) and neutral faces ($M = 4.4$, $SD = 1.2$) as equally arousing, $p = .50$. This age difference occurred because the older participants rated angry faces as less arousing than the younger participants did, $p = .002$. The main effect of Age group was not significant, $F(1,38) = 2.4$, $p = .13$.

Memory Performance

Discrimination index. There was an effect of Expression, $F(2,76) = 4.1$, $\varepsilon = .99$, $p = .016$, showing that discrimination was inferior for happy faces, both *p*s < .014, whereas discrimination was similar for angry and neutral faces, $p = .88$, see Figure 2a. This effect of Expression was not modulated by Age group or Load, all *F*s < 1.1, all *p*s > .40. The effect of Load, $F(3,114) = 200.2$, $\varepsilon = .92$, $p < .001$, showed that discrimination decreased with increasing load, all *p*s < .001. The effect of Age group, $F(1,38) = 16.6$, $p < .001$, showed that older participants had a lower discrimination index than younger participants. Moreover, the significant Load x Age group interaction, $F(3,114) = 6.9$, $\varepsilon = .92$, $p < .001$, indicated that significant age differences were present in loads 2 to 4, all *p*s < .020, but not in load 1, $p = .095$, see Figure 2b.

To control for the potentially confounding effect of the observed age differences in valence and arousal ratings, separate ANCOVAs for each expression were conducted with the covariates Valence rating and Arousal rating, and the factor Age group. Valence rating and Arousal rating had no significant effect on the discrimination index for each expression, all *F*s < 2.1, all *p*s > .15. Moreover, the main effects of Age group, signifying decreased performance in the older compared to the younger adults, remained significant after controlling for age differences in valence and arousal ratings for all expressions, all *F*s > 5.6, all *p*s < .03.

Response bias index. There was a main effect of Expression, $F(2,76) = 12.8$, $\varepsilon = .96$, $p < .001$. The response bias was different for each of the three expressions; it was most conservative for angry faces, slightly liberal for neutral faces, and most liberal for happy faces, all *p*s < .023, see Figure 2c. This effect of Expression was not modulated by Age group or Load, all *F*s < 1.1, all *p*s > .33. Further, there was a significant effect of Load, $F(3,114) = 5.3$, $\varepsilon = .81$, $p = .004$. The response bias decreased from load 1 to 2, $p = .033$, was similar between loads 2 and 3, $p = .83$, and increased again between load 3 and 4, $p < .001$, see Figure 2d. Neither the main effect of Age group, nor the Load x Age group interaction was significant, both *F*s < 1.6, both *p*s > .21.

To control for the potentially confounding effect of the observed age differences in valence and arousal ratings, additional ANCOVAs were conducted for each expression separately. For all expressions, the covariates Valence rating and Arousal rating, and the factor Age group together did not have a significant effect on the response bias index, all *F*s < 1.1, all *p*s > .37.

Sex Differences

To examine the influence of sex of the participant, ANOVAs with the additional factor Sex (male, female) were performed. For the valence ratings, the arousal ratings, and the discrimination index, none of the effects including Sex were significant, all *F*s < 2.0, all *p*s > .15. For the response bias index, the Expression x Sex interaction was significant, $F(2,72) = 4.4$, $\varepsilon = .90$, $p = .019$. Independent samples *t*-tests showed that female participants had a more liberal response than male participants for neutral faces, $p = .003$, but that no sex differences occurred for angry and happy faces, both *p*s > .27. None of the other effects including the factor Sex reached significance, all *F*s < 4.1, all *p*s > .05.

DISCUSSION

The goal of the current study was to investigate the occurrence of age differences in emotional modulation of STM performance. The expression of the to-be-remembered faces influenced memory for face identity in two ways. First, discrimination between faces that were or were not presented previously was increased for angry and neutral compared to happy faces. Second, the response bias was most conservative for angry faces and most liberal for happy faces. Most important for the current research question, no interactions between facial expression and age group were observed on the discrimination and response bias indices. We found no positivity effect or any other age differences in the emotional modulation of STM, even when we controlled for the observed age differences in valence and arousal ratings. The absence of age differences in emotional modulation of STM can be explained in various ways, namely as a consequence of task characteristics, lack of statistical power, or insufficient cognitive control in the older participants, each of which will be discussed in turn below.

The socio-emotional selectivity theory states that the older adults' limited remaining life time urges them to focus on emotion-related goals, while younger adults would focus more on knowledge-related goals (Carstensen, Isaacowitz, & Charles, 1999). But, the more externally constraint a task is, the less influence these emotion goals may have on task performance (Mather, 2006). Indeed, age differences in emotional memory are typically less pronounced in LTM recognition and cued recall tests than in free recall tests (e.g. Langeslag & Van Strien, 2008; Langeslag & Van Strien, 2009). The current STM task resembles LTM recognition tests in the sense that retrieval is guided by the presentation of a probe that requires a forced-choice decision. In addition, assuming that emotion-related goals influence only late stages of processing (Mather & Carstensen, 2005), the influence of these emotion-related goals may have been further reduced by the short time interval between encoding and retrieval phases of the STM task. The valence and arousal ratings tasks, in contrast, were less externally constraint as participants could complete them at their own pace. Indeed, emotion-related goals appeared to have an impact on these rating tasks as age differences in valence and arousal ratings were observed.

The absence of an age effect on the emotional modulation of STM could further have been due to a relative lack of power with 20 participants per age group, even though we did observe effects of age on discrimination in general. With 20 participants per group, power is 80% to detect large effects at a significance level of 10% (Cohen, 1992). Nevertheless, age differences in emotional modulation were absent, even when increasing power by adopting a more lenient significance level (Stevens, 2002) of 20%, or even 30%. Age-independent effects of facial expression, in contrast, were observed with the stringent significance level of 5%. Any modulating effects of age would probably be much smaller than the general effect of facial expression on STM.

It has been suggested that age differences in emotional processing occur only when older adults have sufficient cognitive control (Mather & Carstensen, 2005; Mather, 2006). The current absence of age differences could therefore also have been the result of testing a sample of older adults with inadequate cognitive control or limited resource availability. Although our older adults had completed less formal education than the younger adults, which is a nearly inevitable consequence of generational differences in educational possibilities, they were relatively well-educated and had intact cognitive functioning as assessed by the MMSE. It can therefore be assumed that our older participants' cognitive control was (above) average, thereby satisfying the prerequisite for the occurrence of age differences in emotional processing. Furthermore, although the condition with a memory load of one face was undemanding (as evident from the high and equivalent memory performance of younger and older adults), age differences in the effect of facial expression did not even occur in the low memory load condition. Also the findings of age differences in the valence and arousal ratings of the faces suggests that the absence of age differences in emotional modulation of STM was not due to participant characteristics such as a deficiency in cognitive control. They also dispute the notion that our older participants might not have been old enough for age differences to be detected. Indeed, a positivity effect in LTM has previously been observed with both older and middle-aged adults (Charles et al., 2003). In conclusion, we think that task characteristics rather than a lack of power or participant characteristics are responsible for the absence of age differences in emotional modulation of STM.

In this study, both younger and older adults showed better memory for angry and neutral over happy faces. In previous studies, younger adults remembered angry faces better than happy and neutral faces (Jackson et al., 2008; Jackson et al., 2009) or remembered angry and happy faces better than neutral faces (Langeslag et al., 2009). It is unclear why the present finding of increased discrimination of neutral over happy faces occurred. It could have been due to methodological differences between this and previous studies. In one of the previous studies, participants were required to rehearse a pair of letters subvocally to prevent recruitment of verbal STM processes (Jackson et al., 2009), and in another study participants were instructed to make speeded responses (Langeslag et al., 2009). In a combined genetics and fMRI study, genetic variations have been shown to influence STM for happy faces in particular (Wolf, Jackson, Kissling, Thome, & Linden, 2009). Other individual differences such as affective disposition and personality (see e.g. Feldman Barrett, Tugade, & Engle, 2004; Hamann & Canli, 2004) may have contributed to the discrepancy between this and previous studies as well.

The response bias was most conservative for angry faces and most liberal for happy faces. Compared to neutral faces there was a decreased tendency to indicate that an angry probe face matched the content of memory storage, whereas there was an increased tendency to indicate that a happy probe face matched the content of memory storage. The more liberal response bias for happy compared to neutral faces was in line with our hypothesis, and this liberal way of responding to happy faces appears to have substantially reduced discrimination of these faces. The conservative bias for angry faces was an unexpected finding because previous LTM studies have demonstrated more liberal response biases for both negative and positive stimuli (Grider & Malmberg, 2008; Ochsner, 2000; Windmann & Kutas, 2001). However, in one previous experiment the response bias tended to be more conservative for negative compared to neutral stimuli too (Ochsner, 2000). Notably, in both that previous and the current study, participants were instructed to focus on a non-emotional aspect of the stimulus, namely picture brightness and face identity respectively. More research is needed to examine how response bias for negative and positive information is perhaps differentially affected by the instruction to focus on emotional or non-emotional aspects of a stimulus.

Our investigation of age differences in emotional STM used only three different facial expressions. Although there appears to be a general age-related decline in the ability to label facial expressions, this decline does not appear to be similar for all expressions (Ruffman, Henry, Livingstone, & Phillips, 2008). It would therefore be interesting to examine age differences in emotional STM for faces using faces with other expressions, such as fear, disgust, sadness or surprise, as age differences may be observed in STM for these expressions. In addition, the stimuli used in this study were all male faces, whereas the participants were both men and women. In the analysis of sex differences, it was observed that women had a more liberal response for neutral faces than men. Although this could have been caused by some opposite sex effect, it is unclear why this more liberal response bias would have occurred only for the neutral and not for the emotional faces. Because no effects of participant sex were observed on the discrimination index, the valence ratings and the arousal ratings, we believe that the absence of age differences in emotional modulation of STM is not attributable to the use of male facial stimuli. Still, it might be better to use pictures of both male and female faces in future studies.

To summarize, we report here the first study in which age differences in emotional modulation of STM were investigated in a way that matched previous LTM studies. That is, age differences in the effect of stimulus emotionality on memory for stimulus content were examined. No age differences were observed in the effect of facial expression on STM for face identity. We argue that the current absence of age differences in the emotional modulation of STM is not due to insufficient statistical power or inadequate cognitive control in the older adults. Instead, it might be due to the restricted nature of the STM task. With the mean population age rising, research on the lifespan development of emotional processing, which includes emotional STM, becomes more and more important. Future research could further explore whether, and under what circumstances, age differences in emotional STM occur.

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