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The effect of ageing on the recollection of emotional and neutral pictures

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This study investigated age-related differences in recognition memory for emotional and neutral pictures. Younger and older participants were asked to rate pictures according to their emotional valence, arousal, and visual complexity. Two weeks later they had to recognise these pictures and the states of awareness associated with memory were assessed with the "remember/know/guess" paradigm. We found that, although the influence of emotion on recognition accuracy (as assessed by d′) was similar in both age groups, the tendency for positive and negative pictures to create a rich recollective experience was weaker in older adults. In addition, "remember" responses were more often based on a recollection of emotional reactions in older than in younger participants. We suggest that the elderly tend to focus on their feelings when confronted with emotional pictures, which could have impaired their memory for the contextual information associated with these stimuli.

Numerous studies have provided clear evidence of an age-related decline in episodic memory. These age-related changes vary according to the task that is used, with losses in performance being more pronounced in some tasks than in others. For example, age differences have been found to be greater in tasks involving free or cued recall than in recognition memory tasks (see Balota, Dolan, & Duchek, 2000; Zacks, Hasher, & Li, 2000, for reviews). In addition, there is some evidence that age differences in contextual memory are reliably greater than those in memory for content (see Spencer & Raz, 1995, for a meta-analysis), and it has been found that recognition memory is less often accompanied by a rich recollection of the encoding episode (as assessed by "remember" responses) in older than in younger adults (Bastin & Van der Linden, 2003; Clarys, Isingrini, & Gana, 2002; Mäntylä, 1993; Parkin & Walter, 1992; Perfect & Dasgupta, 1997; Perfect, Williams, & Anderton-Brown, 1995, Experiments 1 & 2B). Overall, these findings suggest that older people are disproportionately affected in their ability to consciously recollect events and the context in which they occurred.

This evidence of an age-related decline in episodic memory comes from studies that have used emotionally neutral words or pictures as stimuli. However, few studies have examined memory for emotional stimuli in ageing, although it has often

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been found that memory is better for emotional than for neutral stimuli in young adults (see Hamann, 2001, for review). Furthermore, existing findings are not completely consistent and it is not yet clear whether the influence of emotion on memory is preserved in older adults and whether it is as strong as in younger adults. We will first review some earlier studies that have examined this issue.

In a study reported by Yoder and Elias (1987), younger and older participants were presented with simple stories in an eight-frame pictorial format. The stories were designed to have either emotional or neutral affective content. Memory for the stories was measured in terms of answers to specific questions (structured recall) and total number of written propositions (free recall). Emotional information was better recalled than neutral information in both structured and free recall situations, and for both young and older participants, which suggests that emotion had similar effects on memory in people of all ages in that study. Similar results were obtained by Carstensen and Charles (1994). Participants in four age-groups ranging from 20 to 83 years old were asked to read a narrative containing equivalent amounts of emotional and neutral information. They then received a surprise recall test 1 hour after the presentation of the texts. There were no significant age-related differences in the amount of emotional material recalled; however, older adults recalled not only less neutral than emotional material but also less neutral information than younger adults. According to the authors, these results suggest that older adults allocate more cognitive resources to the processing of emotional as opposed to neutral information.

Kensinger, Brierley, Medford, Growdon, and Corkin (2002) recently reported on a study in which older and younger adults were given several tests of memory for emotional and neutral stimuli. Participants first saw positive, negative, and neutral pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999) and were asked to classify these pictures as positive, negative, or neutral. They were aware that their memory of these pictures would be evaluated later (intentional learning). In order to avoid ceiling and floor effects, younger adults viewed the pictures once whereas older adults saw them twice. Participants were then given a recall test, in which they were asked to write a brief description of all the pictures they remembered. Pictures with positive and negative affect were better recalled than neutral ones and the magnitude of this memory enhancement for emotional pictures was similar for younger and older adults. Moreover, the two groups did not differ with regard to their recall of positive and negative pictures. Participants were then assessed for their memory of emotional and neutral words. Positive, negative, and neutral words were selected from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999) and participants were asked to rate these words as a function of their emotional valence. The set of words was seen once by younger participants and twice by older participants. For the recall test, they were asked to write all the words they remembered. As was the case for picture recall, emotional words were better recalled than neutral ones and this memory enhancing effect was similar in both age-groups.

Finally, in two studies reported by Charles, Mather, and Carstensen (2003), younger and older participants saw positive, negative, and neutral pictures from the IAPS and, 15 minutes later, were presented with a surprise free recall test and then a recognition memory test. In both studies, older adults recalled fewer negative pictures in relation to positive pictures than younger adults. In addition, younger participants recognised more negative than positive and neutral pictures whereas older adults recognised negative, positive, and neutral pictures equally well. Younger adults performed better than older adults at recognising negative pictures, but not positive and neutral pictures. Thus, contrary to Kensinger et al.'s (2002) findings, these results revealed an age-related decrease in memory for negative stimuli.

Clearly, the results of previous studies are not completely consistent: three studies showed a normal emotional enhancement effect on memory in older adults (Carstensen & Charles, 1994; Kensinger et al., 2002; Yoder & Elias, 1987) and two showed an age-related decrease in memory for negative stimuli (Charles et al., 2003). The reasons for these inconsistencies are unclear at present. The studies present significant methodological differences, however, such as the kind of material (verbal vs pictorial), the nature of the encoding task (incidental vs intentional) and the type of memory task (recall vs recognition), and it could be that these methodological differences are in part responsible for the inconsistent findings. Whatever the case may be, one important issue regarding emotional memory in ageing has not been addressed by these studies. As mentioned above, there is evidence indicating that old people are disproportionately affected in their ability to consciously recollect events and the context in which they occurred. In addition, recent findings suggest that the effect of emotion on memory, and especially the comparison of memory for positive and negative stimuli, is not always reflected in quantitative measurements of memory but may nevertheless be manifest in qualitative aspects of memory such as states of awareness associated with recognition memory (Dewhurst & Parry, 2000; Ochsner, 2000). Accordingly, it would be particularly interesting to examine states of awareness associated with memory in order to better understand how ageing affects the memory for emotional stimuli.

In an unpublished study, Kensinger and Corkin (2002) asked older and younger adults to rate negative and neutral words (incidental learning); after a 5-minute wait, states of awareness associated with recognition memory were assessed with the ‘‘remember/know’’ procedure. The results showed that both age groups gave more ‘‘remember’’ responses for negative than for neutral words and, although ageing affected the ability to recollect (or give a ‘‘remember’’ response), the impairment was lessened when recognising negative words as compared to neutral ones. Thus, the study suggests that the influence of emotion on states of awareness associated with recognition memory is similar in young and older adults. However, Kensinger and Corkin did not assess memory for positive stimuli, leaving unresolved the issue of whether ageing affects memory for positive and negative stimuli in a similar way. In addition, it has been suggested that emotional words may not elicit emotional responses as strong as those induced by validated emotional pictures such as those in the IAPS and, consequently, the emotional processes influencing memory for these two kinds of stimuli may differ (Phelps, LaBar, Anderson, O'Connor, Fulbright, & Spencer, 1998). Furthermore, photos such as those from the IAPS, which depict people, objects, buildings, animals, and both indoor and outdoor scenes, probably tell us more about the influence of emotion on memory in real-world situations than do emotional words.

The purpose of the present study was to further investigate age-related differences in emotional memory by examining the influence of valence and arousal separately. There is a long-running debate in the emotion and memory literature concerning which aspect of emotion—arousal (quantity of emotion) or valence (the positive or negative quality of emotion)—most critically determines how emotion influences memory (see Ochsner & Schacter, 2003). We therefore wanted to examine whether these two dimensions of emotion differentially affect memory in ageing. We presented photos from the IAPS that depicted a variety of people, objects, and scenes. These photos were either positive, negative, or neutral and they also differed with regard to the intensity of the arousal they tended to produce. During encoding, participants were instructed to rate these pictures for valence, arousal, and visual complexity. Two weeks later, they were unexpectedly presented with a yes/no recognition test and the states of awareness associated with recognition memory were investigated with the ‘‘remember/know/guess’’ procedure. In addition, we investigated exactly what older and younger adults remembered from the encoding episode when they made a ‘‘remember’’ response by asking them to explain the basis of their responses (e.g., recollection of a thought they had had, their emotional reaction, a visual detail of the picture and so forth).

Given that, with age, people seem to place ever more value on emotionally meaningful information (see Isaacowitz, Charles, & Carstensen, 2000, for review), it is possible that older adults pay more attention to emotional stimuli than younger adults when encoding new information in memory. This increased attention should favour the encoding of detailed information that could subsequently support rich recollection of the stimuli (Gardiner & Richardson-Klavehn, 2000). This hypothesis was favoured by previous studies that examined emotional memory in ageing and, if it is true, age-related differences in rich recollection situations should be reduced for emotional as opposed to neutral pictures. There is another possibility, however. It may be that, when confronted with an emotional stimulus, older adults tend to focus more on their emotional reaction than do younger adults (Hashtroudi, Johnson, Vnek, & Ferguson, 1994). In that case, older adults would allocate more attentional resources to the affective rather than to perceptual and contextual (spatio-temporal) details associated with emotional pictures; this focus may impair the formation of detailed representations of the perceptual and contextual details of the stimuli (Hashtroudi et al., 1994). These two contrasting hypotheses were examined in the present study.

METHOD

Participants

All participants were healthy at the time of testing. The older group consisted of 20 adults (10 male and 10 female) between 60 and 70 years of age ($M = 67.5$), who lived in their own homes. The younger group consisted of 20 adults (10 male and 10 female) between 18 and 25 years of age ($M = 22.5$). The two groups were matched for years of education ($M = 15.1$ and $M = 15.3$ for younger and older adults, respectively). Vocabulary performance, as assessed by the Mill Hill Vocabulary Scale (French translation by Deltour, 1993), was better for older ($M = 28.6$) than for younger ($M = 23.8$) adults, $t(38) = 4.09$, $p < .01$, a finding that is frequently reported in ageing studies. All participants were right-handed and were native speakers of French.

Materials

A total of 140 photos were selected from the IAPS based on normative ratings of valence and arousal provided by Lang et al. (1999). Two sets (A and B) of 60 photos each were selected as target items and 20 photos served as buffers. Sets A and B contained 20 positive, 20 negative, and 20 neutral pictures and care was taken to equate numbers of high-, medium-, and low-arousal pictures within each set. Also, pictures in each set were matched according to their content so that, for instance, if a photo of ice cream was assigned to set A, a different photo of ice cream was placed in set B. Photos that could not be accurately matched for content were matched for general semantic class (e.g., both animals, but not the same animals). The use of set A or B as studied or non-studied items was counterbalanced across participants.

Four study lists were constructed with stimuli placed in a pseudorandom order such that no more than two stimuli with the same valence (positive, negative, neutral) or arousal (high, medium, low) occurred in succession. Ten buffers were distributed at the beginning and end of each list in order to suppress the primacy and recency effects. Study lists 1 and 2 contained pictures from set A, and lists 3 and 4 contained pictures from set B. To counterbalance for order effects, lists 2 and 4 presented stimuli in the reverse of the orders used in lists 1 and 3, respectively. Two test lists were constructed using pictures from sets A and B presented in a pseudorandom order such that no more than two old or new pictures occurred in succession. The order of presentation of the stimuli in the second test list was the reverse of the order of presentation in the first test list.

Procedure

All participants took part in one study session lasting approximately 30 minutes; two weeks later, they participated in a test session lasting approximately 45 minutes. All photos were presented on a 14.1-inch PC portable display at a viewing distance of approximately 60 cm. During the study session, participants were instructed that their task was to rate photographs of objects, people, and scenes along each of three dimensions: valence, arousal, and visual complexity. No mention was made of the subsequent memory test. Valence ratings corresponded to the feelings one has when looking at a photograph, from 1 (very negative) to 7 (very positive), with a rating of 4 indicating a neutral feeling. Arousal corresponded to the intensity of these feelings, or how aroused one is when looking at the photograph, from 1 (very weak) to 7 (very strong), with a rating of 4 indicating moderate arousal. Visual complexity corresponded to how complex subjects considered the picture to be, from 1 (not at all complex) to 7 (very complex), with a rating of 4 indicating moderate complexity. As in Ochsner's (2000) study, the instructions specified that a picture could be considered complex either because it contained many simple objects, each of which had little detail, or a few complex objects that were all very detailed, or both. On each trial, a fixation cross appeared in the centre of the screen for 750 ms. After a 500-ms pause, a picture appeared on the screen for 2 seconds. When it disappeared, the rating scales for valence, arousal, and visual complexity appeared and stayed on the screen until participants recorded their responses.

Two weeks later, participants were given a recognition memory test. They were told that some old and some new photos would appear on the screen and that their task was first to tell the experimenter which were new and which were old. When a participant claimed to recognise a picture, the states of awareness associated with recognition memory were assessed with the remember/know/guess procedure (see Gardiner & Richardson-Klavehn, 2000, for detailed instructions). Briefly, participants were told that an R response should be given to any photo that brought back to mind something they had consciously experienced at the time it was first presented. For each R response, participants were also requested to justify why they gave a "remember" response and this was written down by the experimenter. This procedure enabled us to make sure that the participants correctly understood the instructions and also to explore the types of characteristics on which "remember" responses were based in both young and older adults. Participants were asked to make a K response if the photo felt familiar but they were unable to recollect any details about its prior exposure. Finally, they were asked to make a G response if they were unsure whether or not the picture had been presented in the study phase and they had guessed. Participants were allowed to report guesses because, when knowing is the default response, it is open to abuse by subjects, who may use "know" responses to reflect various judgemental strategies that do not involve any awareness that the selected item was on the study list (Gardiner & Richardson-Klavehn, 2000). Examples of R, K, and G responses were given and participants were asked to repeat the instructions, to make sure they understood the nature of the task.

RESULTS

Classification of the stimuli

To allow separate analysis of memory performance as a function of arousal and valence, we classified the pictures in both sets A and B according to the valence and arousal ratings participants had given them during encoding, as was done in the studies reported by Ochsner (2000). Mean ratings of valence and arousal were computed for each picture and stimuli were ranked along each of these two dimensions and divided into thirds. Hence, for arousal, the third of the pictures with the highest mean ratings were classified as high-arousal pictures, the third of the photos with the lowest mean ratings were classified as low-arousal pictures, and the photos in between were classified as medium-arousal. A similar procedure was used to classify stimuli along the valence dimension (positive, negative, and neutral).

However, when examining ratings of visual complexity for pictures selected as positive, negative, and neutral, we found that these three categories of pictures differed in their visual complexity, $F(2, 117) = 15.34$, $p < .001$. Similarly, pictures selected as low, medium, and high in arousal differed in their rated visual complexity, $F(2, 117) = 15.05$, $p < .001$. Consequently, the use of these stimuli for analysing recognition memory performance would have posed an interpretation problem because it would not have been possible to disentangle the effects of valence and arousal from those of visual complexity.

In order to avoid this problem, we selected a subset of 10 positive, 10 negative, and 10 neutral pictures from both sets A and B that were matched for visual complexity. With regard to visual complexity, a 2 (age) $\times$ 3 (valence) analysis of variance (ANOVA) revealed that the selected pictures were rated as being more complex by young than by older participants, $F(1, 57) = 62.59$, $p < .001$, but this age effect did not interact with the valence of the pictures, $F(2, 57) = 2.65$, $p > .05$. Similarly, a subset of 10 high-, 10 medium-, and 10 low-arousal pictures matched for visual complexity were selected from both sets A and B. A 2 (age $\times$ 3 (arousal) ANOVA showed that the selected pictures were rated as being more complex by young than by older participants, $F(1, 57) = 41.89$, $p < .001$, but again this group effect did not interact with the arousal level of the pictures, $F(2, 57) = 1.95$, $p > .05$.[1] We now present the analyses of overall recognition memory performance and also qualitative aspects of recognition memory for the pictures selected, along the valence and arousal dimensions separately.[2]

[1] An alternative to avoid the problem that visual complexity of the pictures was perceived significantly differently by younger and older adults would have been to select positive, negative, and neutral (or high-, medium-, and low-arousal) pictures that received equivalent visual complexity ratings by both young and older participants. However, this would have led to the selection of different pictures across age groups, which would clearly pose another problem in interpreting the results. In any case, because age does not interact with valence (or arousal) for visual complexity ratings, if memory for emotional and neutral pictures is differentially affected by ageing, then the findings cannot be attributed to differences in visual complexity.

[2] We also analysed recognition memory data for all the pictures that were presented to the participants during the rating session (i.e., without selecting a subset of pictures matched for visual complexity). Because the results were similar in both types of analyses, we decided to present only analyses for the pictures matched for visual complexity.

TABLE 1
Mean proportions of R, K, and G responses as a function of valence and age

	Remember		*Know*		*Guess*		*Total*	
	Hits	*FAs*	*Hits*	*FAs*	*Hits*	*FAs*	*Hits*	*FAs*
Young								
Negative	0.80	0.01	0.11	0.03	0.03	0.03	0.94	0.07
Positive	0.50	0.01	0.29	0.07	0.09	0.05	0.88	0.13
Neutral	0.41	0.00	0.30	0.02	0.09	0.04	0.80	0.06
Old								
Negative	0.45	0.05	0.21	0.08	0.08	0.07	0.74	0.20
Positive	0.27	0.04	0.28	0.10	0.10	0.07	0.65	0.21
Neutral	0.28	0.01	0.24	0.06	0.11	0.07	0.63	0.14

Yes/no recognition

Valence. Mean proportions of hits and false alarms for the yes/no recognition test as a function of valence and age are presented in Table 1. A 2 (age) × 3 (valence) ANOVA was conducted on the proportion of hits. There was a main effect for age, indicating that the proportion of hits was higher for younger than for older adults, $F(1,38) = 21.93$, $p < .001$. A main effect for valence was also observed, $F(2,76) = 8.52$, $p < .001$. Planned comparisons indicated that the proportion of hits was greater for negative pictures than for positive and neutral pictures, $F(1,38) = 6.37$, $p < .05$, and $F(1,38) = 12.91$, $p < .001$, respectively. The proportion of hits was also higher for positive than for neutral pictures but this difference failed to achieve statistical significance, $F(1,38) = 3.49$, $p = .07$. There was no interaction between age and valence, $F(2,76) < 1$.

Recognition memory performance was also examined by analysing discrimination and bias measures derived from signal detection theory (d' and C; MacMillan & Creelman, 1991).[3] A 2 (age) × 3 (valence) ANOVA showed an effect of age on d', $F(1,38) = 49.74$, $p < .001$, indicating that younger participants ($d' = 2.74$) were better at discriminating targets from distractors than older participants ($d' = 1.60$). An effect of valence was also found, $F(2,76) = 4.95$, $p < .01$. Planned comparisons showed that d' was greater for negative pictures ($d' = 2.41$) than for positive ($d' = 2.03$) and neutral ($d' = 2.08$) pictures, $F(1,38) = 8.12$, $p < .01$ and $F(1,38) = 5.56$, $p < .05$, respectively, and that there were no differences between positive and neutral pictures, $F(1,38) < 1$. There was no interaction between age and valence, $F(2,76) = 1.12$, $p > .05$. With regard to response bias (C), there was an effect of valence, $F(2,76) = 8.07$, $p < .001$, showing that participants' response criterion was more conservative for neutral ($C = 0.34$) than for positive ($C = 0.13$) and negative ($C = 0.07$) pictures, $F(1,38) = 9.68$, $p < .005$ and $F(1,38) = 12.87$, $p < .001$, respectively. No differences in response criterion were observed between positive and negative pictures, $F(1,38) < 1$. No other effects were found (all ps > .05).

Arousal. Mean proportions of hits and false alarms for the yes/no recognition test are presented in Table 2 as a function of arousal and age. A 2 (age) × 3 (arousal) ANOVA was conducted on proportion of hits. There was an effect for age showing that the proportion of hits was higher for younger than for older participants, $F(1,38) = 12.13$, $p < .005$. A main effect for arousal was also observed, $F(2,76) = 6.07$, $p < .005$. Planned comparisons showed that the proportion of hits was higher for high-arousal pictures than for low- and medium-arousal pictures, $F(1,38) = 9.50$, $p < .005$, and $F(1,38) = 7.32$, $p < .05$, respectively. There were no differences between medium- and low-arousal pictures, $F(1,38) = 1.57$, $p > .05$. There was no interaction between arousal and age, $F(2,76) = 1.92$, $p > .05$.

The index of recognition accuracy (d') and response criterion (C) were also analysed. A 2

[3] Signal detection theory uses the hit rate and the false alarm rate to estimate two measures (see MacMillan & Creelman, 1991), d' is the measure of discriminability and C is a complementary measure of response bias. The larger d' is, the better the subject's ability to truly discriminate between old and new items. Values of C above 0 indicate a conservative bias (less willing to guess OLD) whereas values of C below 0 indicate a liberal bias (more willing to guess OLD).

TABLE 2
Mean proportion of R, K, and G responses as a function of arousal and age

	Remember		*Know*		*Guess*		*Total*	
	Hits	*FAs*	*Hits*	*FAs*	*Hits*	*FAs*	*Hits*	*FAs*
Young								
Low	0.35	0.01	0.28	0.02	0.13	0.05	0.76	0.08
Medium	0.55	0.01	0.23	0.03	0.08	0.04	0.86	0.08
High	0.67	0.02	0.18	0.06	0.07	0.03	0.92	0.11
Old								
Low	0.20	0.02	0.33	0.07	0.15	0.06	0.68	0.15
Medium	0.33	0.03	0.25	0.08	0.08	0.05	0.66	0.16
High	0.41	0.03	0.22	0.09	0.11	0.09	0.74	0.21

(age) × 3 (arousal) ANOVA on d' showed an effect of age, $F(1,38) = 28.87$, $p < .001$. Younger participants ($d' = 2.63$) distinguished targets from distractors better than older participants ($d' = 1.67$). No other main effect or interaction was significant (all *p*s > .05). For response criterion (C), the analysis revealed only an effect of arousal, $F(2,76) = 6.93$, $p < .005$. Participants' response criterion was more liberal for high-arousal pictures ($C = 0.05$) than for medium-arousal ($C = 0.28$) and low-arousal ones ($C = 0.31$), $F(1,38) = 12.54$, $p < .005$, and $F(1,38) = 8.99$, $p < .005$, respectively, and there was no difference between medium- and low-arousal pictures, $F(1,38) < 1$.

Remember/know/guess

Valence. Mean proportions of R, K, and G responses are presented in Table 1 as a function of valence and age. A 2 (age) × 3 (valence) ANOVA was conducted on each recognition judgement. A main effect for ageing was observed for R responses, $F(1,38) = 24.75$, $p < .001$, indicating that, overall, young participants gave more R responses than older participants. There was also an effect of valence, $F(2,76) = 39.85$, $p < .001$, and an age by valence interaction, $F(2,76) = 5.19$, $p < .01$. Planned comparisons showed that younger participants reported more R responses for negative than for positive, $F(1,38) = 38.53$, $p < .001$, or neutral, $F(1,38) = 48.4$, $p < .001$, pictures, and that they reported more R responses for positive than for neutral pictures, $F(1,38) = 4.77$, $p < .05$. Older participants also gave more R responses for negative than for positive, $F(1,38) = 14.17$, $p < .001$, or neutral pictures, $F(1,38) = 9.38$, $p < .005$. However, unlike young participants, they reported an equivalent number of R responses for positive and neutral photos, $F(1,38) < 1$. In addition, younger participants gave more R responses than older participants for both positive, $F(1,38) = 14.01$, $p < .001$, and negative, $F(1,38) = 44.33$, $p < .001$, but not for neutral, $F(1,38) = 3.43$, $p > .05$, pictures.

For K responses, no age effect was obtained, $F(1,38) < 1$. There was a main effect for valence, $F(2,76) = 11.87$, $p < .001$, and an age by valence interaction, $F(2,76) = 3.79$, $p < .05$. Planned comparisons indicated that older adults reported more K responses than younger adults for negative, $F(1,38) = 4.22$, $p < .05$, but not for positive, $F(1,38) < 1$, or neutral, $F(1,38) = 1.80$, $p > .05$, pictures.

Finally, there was no age effect for G responses, $F(1,38) = 1.25$, $p > .05$. There was an effect of valence, $F(2,76) = 5.41$, $p < .01$, and planned comparisons showed that there were more G responses for neutral and positive photos than for negative ones, $F(1,38) = 9.24$, $p < .01$, and $F(1,38) = 6.45$, $p < .05$, respectively. There were no differences between neutral and positive pictures, $F(1,38) < 1$. There was no interaction between age and valence, $F(2,76) < 1$.

Arousal. Mean proportions of R, K, and G responses are presented in Table 2 as a function of arousal and age. A 2 (age) × 3 (arousal) ANOVA was conducted on each recognition judgement. For R responses, there was a main effect for group, $F(1,38) = 23.77$, $p < .001$, showing that young participants reported more R responses than older participants. There was also a main effect for arousal, $F(2,76) = 29.94$, $p < .001$. Planned comparisons showed that high-arousal pictures received more R responses than low-,

$F(1, 38) = 45.02$, $p < .001$, or medium-, $F(1, 38) = 10.86$, $p < .005$, arousal pictures. Moreover, medium-arousal pictures were associated with more R responses than low-arousal ones, $F(1, 38) = 24.89$, $p < .001$. There was no interaction between age and arousal, $F(2, 76) = 1.38$, $p > .05$.

For K responses, no age effect was observed, $F(1, 38) < 1$. There was a main effect for arousal, $F(2, 76) = 4.96$, $p < .01$. Planned comparisons showed that high-arousal pictures received significantly fewer K responses than low-arousal pictures, $F(1, 38) = 7.55$, $p < .01$. There were no differences between medium-arousal pictures and high- or low-arousal pictures, $F(1, 38) = 2.03$, $p > .05$, and $F(1, 38) = 3.77$, $p > .05$, respectively. There was no interaction between age and arousal, $F(2, 76) < 1$.

Finally, there was no significant difference between age groups for G responses, $F(1, 38) < 1$. There was an effect of arousal, $F(2, 76) = 4.58$, $p < .05$, and planned comparisons showed that low-arousal pictures received more G responses than medium- and high-arousal ones, $F(1, 38) = 7.22$, $p < .05$, and $F(1, 38) = 5.16$, $p < .05$, respectively. Medium-arousal and high-arousal photos received an equivalent number of G responses, $F(1, 38) < 1$. There was no interaction between age and arousal, $F(2, 76) < 1$.

Justifications for ‘‘remember’’ responses

In order to explore age-related differences in the reasons for R responses, two blind raters independently classified the justifications participants gave for their R responses into three categories according to their content. The first category concerned R responses that were based on the memory of the emotional reaction or feeling participants had had when they saw the picture. The second category included justifications that were based on the memory of some perceptual details of the stimuli. Finally, the third category concerned justifications that were based on the memory of a thought or a personal association that participants had had during encoding. When a response included elements relevant to more than one category, the raters were asked to classify the response according to its most salient aspect. The two raters agreed on the classification of 83% of the 646 responses, a reasonably good degree of concordance. Afterwards, the raters met and reached a consensus on all discrepancies.

We then computed, for each participant, the proportion of R responses that were assigned to each category. The mean proportions are presented in Table 3 as a function of age and category. A 2 (age) $\times$ 3 (category) ANOVA on these proportions revealed an effect of category, $F(2, 76) = 7.67$, $p < .001$, and an age by category interaction, $F(2, 76) = 3.17$, $p < .05$. Planned comparisons indicated that R responses were based on a recollection of emotional reactions more often in older than in younger adults, $F(1, 38) = 4.77$, $p < .05$. By contrast, R responses tended to be based on a recollection of thoughts more often in younger than in older adults, but this difference just failed to reach statistical significance, $F(1, 38) = 3.29$, $p = .07$. The two groups did not differ concerning the proportions of R responses that were based on a recollection of perceptual details, $F < 1$.

DISCUSSION

The aim of this study was to examine age-related differences in recognition memory for emotional and neutral pictures. Younger and older adults were presented with pictures that were subsequently classified according to two different dimensions of emotion, namely valence and arousal, as rated by the participants themselves. Recognition memory for these pictures was assessed by analysing both quantitative aspects of recognition (hits and d') and the states of awareness that accompany recognition memory. In addition, the content of rich recollections of the stimuli (as assessed by ‘‘remember’’ responses)

TABLE 3
Mean proportions of R responses that were based on recollection of emotions, perceptual details, or thoughts, as a function of age

Age	*Emotional reactions*	*Perceptive details*	*Thoughts*
Young	0.31	0.23	0.46
Old	0.45	0.20	0.35

was analysed in order to explore age-related differences in the basis for recollection of the stimuli.

First, with regard to overall recognition accuracy (d'), we found that, although recognition memory was better for younger than for older participants, the influence of emotion was the same in both groups: for valence, negative pictures were better recognised (as assessed by both proportion of hits and d') than positive and neutral ones, with no differences between the latter two; for arousal, although high-arousal pictures received more hits than both medium- and low-arousal pictures, there were no significant differences between the three groups of pictures for index of recognition accuracy (d'). The results concerning the influence of valence on recognition accuracy are consistent with previous findings in young subjects (Ochsner, 2000). The absence of an arousal effect on recognition accuracy (d') that was found in our study was also reported by Ochsner in one of his experiments with young subjects (2000, Exp. 3). However, Ochsner found that arousal affected recognition accuracy in two other studies (Exps 1 and 2). The reasons for this discrepancy are unknown and merit further investigation.

Although the influence of emotion on memory was the same in younger and older adults when quantitative measures of recognition memory (hits and d') were examined, we found age-related differences in the states of awareness associated with recognition memory for emotional pictures. Indeed, with regard to valence, positive and negative pictures were richly recollected more often than neutral ones by younger adults, which is consistent with a previous study (Ochsner, 2000), whereas older adults reported more R responses for negative but not for positive pictures. Furthermore, older adults reported fewer R responses than younger adults for positive and negative but not for neutral pictures. Turning to the dimension of arousal, we found that high-arousal pictures were more often associated with an R response than medium- and low-arousal pictures, and that medium-arousal pictures were more often associated with an R response than low-arousal pictures. Therefore, arousal influenced qualitative aspects of recognition memory (recollective experience) but not recognition accuracy. In contrast to the findings concerning valence, the influence of arousal on states of awareness was similar in young and older participants.

To the best of our knowledge, only two previous studies have examined age-related differences in memory for emotional and neutral stimuli similar to those we used in the present study. Kensinger et al. (2002) found that both younger and older adults recalled more positive and negative pictures than neutral pictures; positive and negative pictures were equally well recalled. Furthermore, there was no age effect and no age by valence interaction on recall performances. The authors interpreted their findings by proposing that ageing is associated with a normal enhancement of memory for emotional stimuli. In contrast, Charles et al. (2003) found that the relative number of negative pictures compared to positive and neutral pictures recalled decreased with age. In addition, younger participants recognised more negative than positive and neutral pictures whereas older adults recognised negative, positive, and neutral pictures equally well. Also, younger adults recognised negative pictures better than older adults, but not positive and neutral pictures. Charles et al. interpreted their findings as suggesting that ageing is associated with a decline in memory for negative stimuli because emotional regulation is typically more effective in older than in younger adults, which may reduce the impact of negatively valenced experiences in older people. The findings of the present study are still different: we found that the effect of valence and arousal on overall recognition memory performance (as assessed by either proportion of hits or d') was similar in both younger and older adults. Therefore, unlike Charles et al., we did not find a specific age-related decrease in memory for negative stimuli and the results concerning overall recognition memory are more consistent with those reported by Kensinger et al. However, we found age-related differences in the states of awareness associated with recognition memory for emotional stimuli, with older adults showing a decrease in R responses both for negative and positive, but not for neutral, pictures.

It is difficult to identify the reasons for the discrepancies in the findings of these three studies. Several variables could have played a role, although their influence is currently unclear and would merit further investigation. First, the waiting period between study and test may influence age-related differences in memory for emotional stimuli. In the studies of Kensinger et al. (2002) and Charles et al. (2003), the period between study and test was very short (no delay in the study of Kensinger et al., and 15 minutes in the Charles et al. study), whereas it was 15 days in our study. Several studies with young adults have found that the influence of emotion on memory increases with the retention interval, especially with regard to memory for contextual details associated with emotional events (see Christianson, 1992; Heuer & Reisberg, 1992, for reviews). Also, neuroscience research has shown that emotion modulates long-term memory consolidation, a process that takes place gradually over time (Hamann, 2001; McGaugh, 2000). One possible explanation for the poorer recollection of positive and negative pictures by older adults in this study would be that this memory enhancement effect for the details of emotional events over time is reduced in older adults. In future, research manipulating the retention interval should be conducted in order to clarify this issue.

Another factor that would merit further investigation concerns the instructions given to participants during the study phase. Whereas participants intentionally learned the pictures in Kensinger et al.'s (2002) study, learning was incidental in both Charles et al.'s (2003) study and this one. It could be that the differences between the Kensinger et al. and Charles et al. studies with regard to recall of negative pictures in ageing were due to differences in the encoding process; more controlled processes and strategies may have been used to encode stimuli in the Kensinger et al. study. It should be noted that studying age-related differences in emotional memory with an incidental memory paradigm probably tells us more about memory for everyday emotional events, which are seldom consciously encoded in memory.

A striking finding of the present study was that age-related differences in memory for emotional stimuli were only apparent when qualitative indices of recognition memory were taken into account. This suggests that how memory performance is measured may influence findings about age-related differences in memory for emotional stimuli. To the best of our knowledge, our study is the first one to investigate age-related differences in states of awareness associated with recognition memory for emotional and neutral pictures. As we have already mentioned, Kensinger and Corkin (2002) found that the decrease in R responses with age was less significant for negative than for neutral words, which is inconsistent with our findings. However, as suggested by Phelps et al. (1998), the processes involved in the enhanced memory for emotional words are probably not the same as those involved in the enhanced memory for emotional pictures because words typically do not produce emotional reactions (i.e., arousal) as strong as those produced by pictures.

Although the retention interval, the encoding task, and the type of memory test could be responsible for discrepancies in findings about emotional memory in ageing, the effects of these variables are still unclear at present. Be that as it may, our findings concerning the states of awareness associated with positive, negative, and neutral pictures suggest that the tendency of emotional stimuli to create a rich recollective experience is weaker in older adults, at least after a relatively long retention interval (i.e., 15 days). This finding is consistent with the second possibility we mentioned in the introduction. That is, when confronted with stimuli that elicit an emotional reaction, older adults may focus on their feelings more than younger adults (Hashtroudi et al., 1994). As a consequence of this emotional self-focus, they may allocate fewer resources to encoding the perceptual and contextual details of the stimuli and hence rich recollections are less likely to occur. Thus, we propose that, when confronted with events that induce an emotional reaction, older people remember the emotional aspects of the events (i.e., their own emotional reaction) better than younger adults, but at the expense of other aspects. Our findings that R responses by older adults were more often associated with a recollection of the subject's emotional reaction when a stimulus was seen and less often associated with the recollection of a thought or an association formulated during encoding are consistent with this proposition. It should be noted that this proposition does not imply that older adults always remember contextual information associated with emotional stimuli less well than younger adults. We suggest that this is the case only when stimuli produce sufficient emotional reaction to make older people focus on their own feelings rather than on other aspects of the event. Future studies are needed in order to explore this proposition in more detail.

Finally, in the present study and previous ones (Dewhurst & Parry, 2000; Ochsner, 2000), negative stimuli were richly recollected more often than positive stimuli and we found this to be true of both young and older adults. This suggests that negative information is better encoded and/or better consolidated in memory than positive information. Taylor (1991) proposed that individuals tend to engage more cognitive resources when confronted with negative rather than positive or neutral stimuli. From an evolutionary perspective, negative stimuli would play a greater role than positive stimuli in providing useful information for the survival of an organism; being able to experience a threatening event over again in memory could offer a distinct advantage in planning for future similar encounters (LeDoux, 1996). This way of responding to unpleasant stimuli with extensive cognitive activity might account for negative pictures being more richly recollected than positive pictures. It should be noted, however, that memory for positive versus negative information seems to be quite different when different types of stimuli are used. In particular, memory tends to be better for positive rather than negative information when the stimuli are relevant to the subject's self-concept, such as adjectives (Denny & Hunt, 1992) or propositions (Sedikides & Green, 2000) describing personality traits. In addition, we have recently found that stimuli that give important social feedback to the self, such as faces, are better remembered (as assessed by R responses) when they were previously encountered with a positive rather than a negative emotional expression, by both young and older adults (D'Argembeau & Van der Linden, 2004; D'Argembeau, Van der Linden, Comblain, & Etienne, 2003).

In conclusion, our findings provide further evidence that emotion tends to enhance the accuracy of recognition memory. Furthermore, they are consistent with previous studies showing that recognition based on recollected experience is more frequent for positive and negative than for neutral pictures in young adults. In contrast, we found that this ability of positive and negative pictures to create a rich collective experience was weakened in older adults. We also found that rich recollections of stimuli were more often based on a recollection of emotional reactions in older than in younger participants. Based on these findings, we suggest that a tendency on the part of the elderly to focus on their feelings when confronted with emotional stimuli may impair their memory for the contextual information associated with these stimuli, thereby producing a decrease in recollection.

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