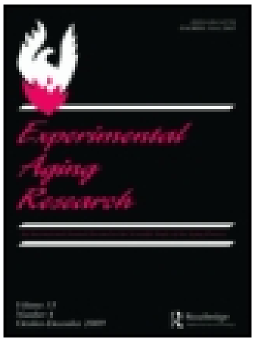

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The Influence of Discrete Negative and Positive Stimuli on Recognition Memory of Younger vs. Older Adults

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ABSTRACT

Background: The effects of emotional stimuli on memory in older adults are often addressed in terms of socio-emotional selectivity theory and the valence dimension. Older adults usually remember positive stimuli better than negative stimuli. However, studies examining the effects of discrete emotions on the elderly are still limited. The present study examined the effects of negative and positive discrete emotions (fear, disgust, and happiness) on recognition memory of older and younger adults.
Method: In the encoding phase, participants studied happiness-, disgust-, fear-, and neutral- related photos while doing a line discrimination task that assessed their attention. After 45 minutes, they completed an old/new recognition memory test on a confidence rating scale and also rated self-relevance of photos.
Results: Younger participants showed a more liberal response bias for disgust- and fear-related stimuli, and were also more accurate in recognizing disgust-related photos compared to others. Older adults showed a more liberal bias only for disgust-related stimuli, however, their recognition accuracy did not differ across emotion categories.
Conclusion: These results suggested that the effect of disgust-related stimuli on recognition memory may decrease with age and emotion effects cannot solely be accounted for by the valence/arousal dimensions.

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Introduction

Numerous studies previously reported that emotional stimuli enhanced memory performance compared to neutral stimuli (see Kensinger & Schacter, 2008; for a review). A common approach employed in the emotional memory literature is the dimensional model which broadly defines emotions along two dimensions: valence (positive to negative) and arousal (calm to exciting) (Russell, 1980). The majority of studies investigating the effect of valence on memory suggested that negative stimuli attracted more attention and were remembered better than positive stimuli in younger adults (Kensinger, 2007; for a review). Memory advantage for negatively-valenced items is known as the negativity bias (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). The negativity bias indicates that negative emotional stimuli carry prioritized survival value compared to positive stimuli and remembering negative information increases the chances of survival. In addition, research reported robust effects of negatively-valenced items on response bias as well as on memory accuracy: younger adults show more liberal bias (willingness to say "old") to negative

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stimuli rather than positive or neutral stimuli (e.g., Dougal & Rotello, 2007; White, Kapucu, Bruno, Rotello, & Ratcliff, 2014; Windmann & Kutas, 2001).

More recently, emotional memory has also been studied with a discrete emotions approach, according to which basic emotion categories of happiness, sadness, surprise, anger, fear, and disgust have distinct, specific functions and evolutionary importance (Keltner & Gross, 1999). The findings of these studies have shown that emotions that are similar in terms of valence and arousal have different effects on attention and memory processes. For instance, Chapman and colleagues (Chapman, Johannes, Poppenk, Moscovitch, & Anderson, 2013) examined memory performance for disgust-related and fear-related photos that were matched for valence, arousal, and visual factors such as luminance and contrast. They reported that disgust-related photos attracted more attention and enhanced memory performance compared to the fear-related or neutral photos when memory was tested after 45 minutes and even after 1 week. Similarly, younger adults recognized disgust-related words better than their neutral counterparts, compared to the fear- or anger-related words (Kapucu & Rotello, revision submitted).

The advantage of disgust on cognitive processing has been demonstrated in several studies of attention (van Hooff, Devue, Vieweg, & Theeuwes, 2013; van Hooff, van Buuringen, El M'rabet, de Gier, & van Zalingen, 2014; Xu et al., 2016) and memory (Chapman, 2018; Charash & McKay, 2002; Croucher, Calder, Ramponi, Barnard, & Murphy, 2011; Ferré, Haro, & Hinojosa, 2018; Marchewka et al., 2016). While *fear* protects organisms from life-threatening situations and external harm by triggering appropriate responses (Davis, 1997), *disgust* signals potential disease and pathogen threat (Curtis, Aunger, & Rabie, 2004). Objects which are considered disgusting cause contamination of clean objects through contact; this contamination threat causes us to notice and remember these stimuli (Rozin & Fallon, 1987).

Overall, these findings indicated that disgust-related stimuli enhance attention and memory performance compared to fear-related or neutral stimuli. The studies mentioned so far, however, were all conducted with younger adults. There are considerably less information on discrete emotions effects on memory of older adults; whether or not the effects of disgust and fear on younger adults' memory and attention processes would also generalize to those of older adults still remains as an open question.

The vast majority of the literature on ageing and emotion have adopted a dimensional approach, focusing on the effects of valence on cognitive ageing. These studies found that, contrary to younger adults, older adults did not show the negativity bias and had better memory performance for positive stimuli than for negative stimuli (e.g., Mather, 2006; Reed, Chan, & Mikels, 2014). In recognition memory tests, older adults also showed an increased response bias to positive stimuli (Kapucu, Rotello, Ready, & Seidl, 2008). The tendency of older adults to favour positive information is called the age-related positivity effect (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2003). The positivity effect is accounted for by the Socio-emotional Selectivity Theory (SST; Carstensen, 2006) which suggests that time perspective influences people's goals in life: those who perceive time as more limited, such as the older adults, focus more on emotionally meaningful goals (Carstensen, Isaacowitz, & Charles, 1999; Charles et al., 2003). Thus, their emotion regulation ability improves, and positive information is prioritized. The positivity effect has been observed in emotional experiences (Charles, Reynolds, & Gatz, 2001; Stone, Schwartz, Broderick, & Deaton, 2010), attention (Knight et al., 2007; Mather & Carstensen, 2003), recall and recognition memory (Bruno, Brown, Kapucu, Marmar, & Pomara, 2014; Charles et al., 2003; Mather & Knight, 2005), working memory (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005), and autobiographical memory (Kennedy, Mather, & Carstensen, 2004). However, some studies did not support SST as they reported a lack of positivity bias in emotional perception (e.g., Houston, Pollock, Lien, & Allen, 2018), attention (e.g., Thomas & Hasher, 2006), and recognition memory (e.g. Allen et al., 2019; Kapucu et al., 2008). In addition, some researchers argued for a decreased negativity bias rather than an increased positivity in older adults (Mienaltowski, Corballis, Blanchard-Fields, Parks, & Hilimire, 2011; Wood & Kisley, 2006).

Although, the age-related positivity effect has been extensively researched, there is only a limited number of studies that examined the effects of discrete emotions on cognitive aging (Allard & Hamilton, 2019; Kunzmann, Kappes, & Wrosch, 2014; Kunzmann, Kupperbusch, & Levenson, 2005). Most of these studies have focussed on the recognition of emotional expressions and emotional experience. Research on ageing and emotional experience have shown age-related differences in the experience of happiness, disgust and fear. As people age, happiness experiences increase (Mroczek & Kolarz, 1998). In contrast, disgust sensitivity declines (Curtis et al., 2004), and the older adults experience disgust less than the younger adults (Kunzmann et al., 2005). As for fear experiences in older adults, the results are mixed. Research showed that fear experience sometimes decreased (especially in social situations) (Mohlman, Lauderdale, & Wuthrich, 2020), yet sometimes did not change with age (Gould & Edelstein, 2010; Gross et al., 1997). Some researchers, however, have drawn attention to an age-related increase in fear with regards to issues of health (fear of falling, illness, diminishing in health and care for oneself) or death (own or of loved ones) (Kogan & Edelstein, 2004). Similarly, Teachman and Gordon (2009) pointed out that older adults experienced fear more than younger adults due to the deterioration of physical health.

To sum up, previous research has shown that disgust-related stimuli had an advantage in attention and memory in younger adults. With age, disgust experiences decline and, especially health-related fear experiences increase, however, little is known about the effects of disgust and fear on memory processes in older adults. In the present study, we examined the recognition memory performance of younger and older adults for disgust-related, fear-related, happiness-related, and neutral stimuli. Our main purpose was to replicate Chapman et al. (2013)'s design to explore whether the disgust-related memory advantage for younger adults could also be generalized to the older adults.

Consistent with Chapman et al. (2013) findings, we hypothesized that younger adults would remember disgust-related stimuli better than fear-related, happiness-related or neutral stimuli, regardless of response bias. For older adults, we predicted that the effect of discrete emotions on memory would parallel the age-related changes in emotional experience. Accordingly, older adults would remember happiness-related stimuli better than others. Furthermore, older adults would become less sensitive to disgust-related stimuli due to reduced disgust experience, and their memory for those stimuli would be worse than that of the younger adults. In contrast, older adults may become more sensitive to fearful stimuli due to their changing precedency, and they would remember fear-related stimuli better than disgust-related stimuli. In addition to memory accuracy effects, we expected older adults to also respond more liberally to both positive (happiness-related) and negative (fear- and disgust-related) stimuli than neutral ones (Kapucu et al., 2008), whereas younger adults would show this liberal bias only to negative, but not to positive, items. We also examined the relationship between self-relevance of stimuli and memory performance. Apart from the dimensional and discrete emotion effects on memory performance, self-relevance of stimuli is another important factor that have been focussed on in recent memory research (Montagrin, Brosch, & Sander, 2013; Tomaszczyk, Fernandes, & MacLeod, 2008). Following previous studies, we predicted that both younger and older participants would be better able to remember stimuli that were most relevant to their goals and motivations.

Method

Participants

46 psychology students from Ege University were recruited for the younger sample. 3 participants were excluded due to technical reasons (n = 1) and incomplete data (n = 2). 35 volunteering adults from the community were recruited for the older sample. The inclusion criteria were 60 years of age or older, a Mini-Mental State Examination (MMSE; Babacan-Yıldız et al., 2016; Folstein, Folstein, & McHugh, 1975; Gungen, Ertan, Eker, Yasar, & Engin, 2002) score of 24 or higher and the Geriatric Depression Scale (Ertan, Eker, & Sar, 1997; Yesavage et al., 1983) score of 11 of lower. 9 older participants were excluded who had a high depression score (n = 4), experienced technical problems (n = 2), or did not complete the experiment (n= 3).

The final sample included 43 younger adults (33 females) between the ages of 19–28 (M = 20.91, SD = 1.48) and 26 older adults (13 females) between the ages of 60–89 (M = 68.65, SD = 6.38). All participants had normal or corrected-to-normal vision. All participants were informed about the general process of the study and they signed a voluntary participation form. This study has been approved by Ege University Scientific Research and Publication Ethics Committee (EGEBAYEK).

Materials

Stimuli

Stimuli were selected via a pilot study. 180 photographs were pooled from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), Chapman et al.'s (2013) study and internet search. Forty younger (27 female, 18–23 years of age) and 19 older (8 females, 60–74 years of age) adults rated each photo on the intensity of discrete emotions (happiness, sadness, fear, disgust, surprise, and anger) (0- "not at all" – 8- "extremely"), valence and arousal evoked by each image (***valence***: 1- "unpleasant"- 9 – "pleasant"; ***arousal***: 1- "calm" – 9 – "aroused").

Based on participants' ratings, 120 photos (30 disgust-, 30 fear-, 30 happiness-related, and 30 neutral) were chosen for the present study. Selected photos elicited one specific emotion in accordance with the emotion category they belonged. Table 1 presents the mean ratings for the target emotion, valence, and arousal of the selected photos. For both younger and older adults, selected disgust-, fear- and happiness-related photos had higher target emotional intensities than non-target emotions. Disgust- and fear-related photos were matched on mean arousal for both younger and older adults. Disgust- and fear-related

Table 1. Mean of target emotion, valence and arousal ratings for pilot study.

		Disgust	Fear	Happiness	Neutral
Younger	Target Emotion	5.93 (*SE* = 0.23)	4.46 (*SE* = 0.13)	6.08 (*SE* = 0.21)	-
	Valence	1.82 (*SE* = 0.09)	2.41 (*SE* = 0.11)	7.72 (*SE* = 0.12)	5.36 (*SE* = 0.13)
	Arousal	6.22 (*SE* = 0.19)	6.23 (*SE* = 0.10)	4.50 (*SE* = 0.11)	3.73 (*SE* = 0.07)
Older	Target Emotion	5.59 (*SE* = 0.26)	4.98 (*SE* = 0.23)	6.36 (*SE* = 0.16)	-
	Valence	2.06 (*SE* = 0.17)	2.13 (*SE* = 0.12)	7.63 (*SE* = 0.18)	3.38 (*SE* = 0.14)
	Arousal	5.42 (*SE* = 0.15)	5.78 (*SE* = 0.14)	4.01 (*SE* = 0.22)	5.94 (*SE* = 0.10)

photos were also matched on mean valence for older participants, however, younger participants rated disgust-related photos more negative than fear-related photos. Please see the Appendix for further details.

Selected 120 photos included 30 photos from each emotion category. Disgust-related photographs contained insects (e.g., cockroaches), pollution, spoiled food or body products (e.g., vomit, faeces). Fear-related photos were pictures of threatening animals, violent actions, illness-death (e.g., hospital, surgery, cemetery) or disasters (e.g., plane crash, flood). Happiness-related photos contained children, cute animals or happy couples. Finally, the neutral category included images of inanimate objects or daily actions. Half of the photos were used as targets (15 from each category, 60 total), and the other half was used as lures (15 from each category, 60 total) in the recognition memory task. In addition, luminance levels of the selected photos were matched using MATLAB and Adobe Photoshop.

Questionnaires

Future Time Perspective Scale (FTP; Carstensen & Lang, 1996) was used to examine long or constrained time horizon of participants on a 7-point scale (1- "very untrue" – 7- "very true"). High scores indicate long-time horizons and low scores indicate limited-time perception.

Global emotional experiences of participants during the last 2 weeks were measured via a list of emotional items (İyilikci & Amado, 2018). This list includes eight emotions (calm, happiness, anger, sadness, disgust, fear, attention, and surprise) and 22 additional items related to these emotions (disgust score was measured from items of *disgusted, nauseated,* α =.87; fear was measured from items of *afraid, scared, shuddered,* α = .70; happiness was measured from items of *happy, joyful, cheerful,* α = .78, for our sample). Participants were asked to assess to what extent they experienced each emotion on a 5-point Likert scale (1- "none"- 5- "always"), considering their general mood during the last 2 weeks.

Procedure

Figure 1 illustrates the sequence of events throughout the experiment. After signing informed consent, participants were randomly assigned to one of the lists. Stimuli were presented with OpenSesame 3.0 software (Mathôt, Schreij, & Theeuwes, 2012). During the encoding phase, participants viewed a total of 60 photos (15 disgust, 15 fear, 15 happiness, 15 neutral). The photos (25.4 × 19.05 cm) were presented at the centre of the screen and participants were seated at an approximate distance of 50 cm from the screen (28 × 21 degrees of visual angle). Each trial started with a fixation point

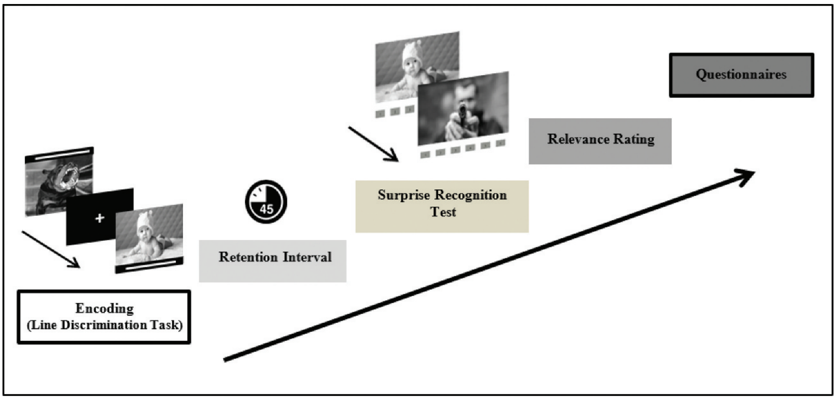

Figure 1. Sequence of events in the experiment. Note: Presented stimuli in Figure 1 were not original because of copyright reasons.

presented for 500 ms., followed by the presentation of a photograph (for 2000 ms. for younger participants, and for 3000 ms. for older participants). The line discrimination task (Chapman et al., 2013) was used to assess attention toward images. A horizontal line (25.4 × 0.78 cm; 28 × 0.9 degrees of visual angle) was presented above or below the photograph for 700 ms. for younger adults and for 2000 ms. for older adults. For younger adults, the line presentation time was determined based on Chapman et al. (2013; Exp, p. 2). The line was presented longer for the older adults to maintain their RT performance at a certain level. Participants' task was to indicate the location of the line as quickly as possible by pressing the appropriate button on the keyboard. Participants were told that they should pay attention to the photographs as well as the line. They were not informed of an upcoming memory test.

After the encoding phase, there was a 45-min. interval until the recognition test. No filler tasks were given; participants spent this time as they wished. For the recognition test, participants were presented 30 photos (15 old, 15 new) from each emotion category, one at a time, and were asked to decide whether or not they had seen the picture during the encoding phase. They made this old/new judgment on a 6-point confidence rating scale (1- "sure new" – 6- "sure old").

Following the recognition test, participants rated the self-relevance or significance of all 120 photographs, presented one at a time on the screen, on a 7-point scale (1- "highly personally irrelevant" – 7- "highly personally relevant"). At the end of the study, all participants completed the Future Time Perspective Scale and the list of emotional items. Additionally, older adults completed the MMSE and the Geriatric Depression Scale.

Results

Data are available via the Open Science Framework: https://osf.io/3a9sh/

Recognition Memory Performance

Receiver Operating Characteristic (ROC) analyses were employed to examine memory accuracy independently of response bias (Macmillan & Creelman, 2005). Figure 2 shows ROC curves for each item type in each emotion category for both age groups. Participants' confidence ratings were used to create the ROC curves which plot the hit rate, P("old"|targets), against the false-alarm rate, P("old"|lures), at each level of confidence. Curves higher on ROC space represent higher accuracy; points that fall along a common curve reflect equal accuracy but different response biases. Points shifted toward the upper right corner (1,1) reflect higher "old" response rates to both targets and lures, indicating more liberal response biases.

The area under the ROC curve (*AUC*) was estimated as a measure of recognition accuracy and criterion value ($c = -0.5\,[Z(H) - Z(F)]$) was estimated as a measure of response bias for each participant and emotion category individually (Rotello, Masson, & Verde, 2008). Higher values of *AUC* imply higher memory accuracy and lower values of *c* reflect more liberal response biases. Table 2 shows mean accuracy and bias values for each item type in each emotion category for both age groups.

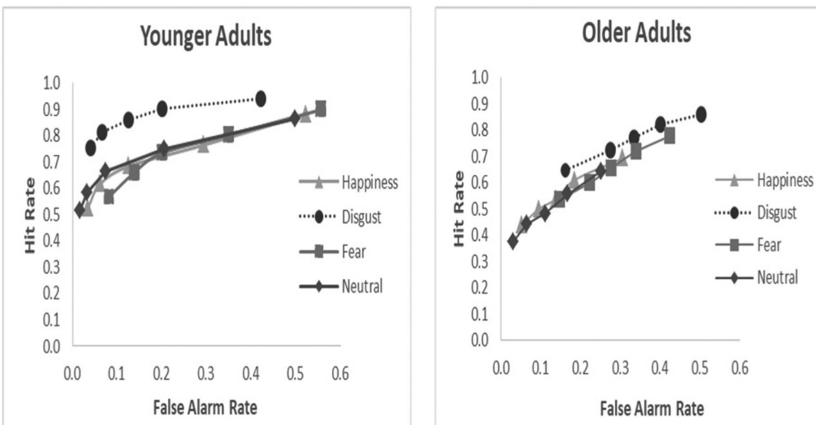

Figure 2. ROC Curves for both younger and older adults.

Table 2. Mean accuracy (*AUC*) and bias (*c*) values (with standard errors) in each emotion category for both age groups.

	Younger Adults		Older Adults	
	AUC	c	AUC	c
	M (SE)	M (SE)	M (SE)	M (SE)
Disgust	0.95 *(0.01)*	0.20 *(0.08)*	0.78 *(0.02)*	−0.15 *(0.10)*
Fear	0.84 *(0.02)*	0.15 *(0.07)*	0.73 *(0.02)*	0.14 *(0.10)*
Happiness	0.85 *(0.02)*	0.47 *(0.08)*	0.75 *(0.02)*	0.63 *(0.10)*
Neutral	0.85 *(0.02)*	0.71 *(0.08)*	0.73 *(0.02)*	0.84 *(0.11)*

A 4 (emotion category: disgust, fear, happiness, neutral) × 2 (age: younger, older) mixed ANOVA[1] with emotion category as the within-subject factor and age as the betweensubjects factor revealed a significant main effect of age on accuracy (*AUC*): memory performance was higher in younger adults compared to older adults, F (1, 64) = 39.231, $p < .001$, $\eta_p^2 = .38$. Main effect of emotion on accuracy was also significant, F (3, 192) = 13.159, $p < .001$, $\eta_p^2 = .17$. Disgust-related photos were recognized better than those in other emotion categories (all p's < .001); accuracy was similar across fear, happiness, and neutral categories, all p's = 1.0. There was also a significant Age × Emotion interaction, F (3, 192) = 2.80, p= .041, $\eta_p^2 = .042$. Younger adults recognized disgust-related photos better than those in other emotion categories (all p's < .001) but memory accuracy did not differ across emotion categories in older adults, all p's > .252.

When the same analysis was conducted on response bias (*c*), the main effect of age was not significant, $F < 1$. Main effect of emotion, however, was significant, F (3, 201) = 53.99, p< .001, $\eta_p^2 = .446$; participants responded more liberally (higher "old" response rates) to negative stimuli (disgust and fear) than for positive (happiness) or neutral, all p's < .001. However, disgust- and fear-related photos did not differ, p= .30. Participants also responded more liberally to happiness-related stimuli compared to neutral ones, $p < .01$.

Age x Emotion category interaction was also significant, F (3, 201) = 6.098, p= .001, $\eta_p^2 = .083$. Disgust- and fear-related photos did not differ in terms of response bias for younger adults ($p = 1.0$). However, younger adults responded more liberally to both disgust- and fear-related stimuli compared to happiness-related or neutral stimuli, all p's < .05. In addition, happiness-related photos yielded a more liberal bias than neutral photos in younger adults, p= .016. In contrast, older adults were more liberal in their bias to disgust-related photos than to fearful, happy or neutral photos, all p's < .05. Fear-related photos also yielded a more liberal bias compared to happy or neutral photos in older participants, all p's < .001. Yet, happiness-related and neutral stimuli did not differ, $p = .22$.

Line Discrimination Task

Following Chapman et al. (2013), participants' mean reaction time (RT) on the line discrimination task was used as a measure of attention to stimuli during encoding. Figure 3 shows the mean RT values in each emotion category for both age groups. A 4 (emotion category) × 2 (age) mixed ANOVA on mean RT revealed that both main effects were significant: Age = F (1, 67) = 99.078, $p < .001$, $\eta_p^2 = .597$; Emotion = F (3, 201) = 7.372, $p < .001$ $\eta_p^2 = .099$. Older adults were generally slower in detecting the line than younger adults. Participants were faster in detecting the line presented with happiness-related photos than with disgust-related or fear-related photos, all p's < .05, but RTs did not differ between happiness and neutral categories, $p = .44$. The line detection time was also similar across disgust, fear, and neutral categories, all p's > .11.

The interaction between age and emotion was also significant on RTs, F (3,201) = 5.276, $p < .01$, $\eta_p^2 = .073$. Line detection time did not differ across emotion categories in younger adults, (all p's >.85), however, older adults were slower in detecting the line presented with disgust-related photos than with happy or neutral photos (all p's <.01), indicating that they paid more attention to disgust-related stimuli. Fear-related photos also captured more attention (longer RTs) than happiness-related photos in older adults *($p < .01$);* none of the other comparisons was significant, all p's > .13.

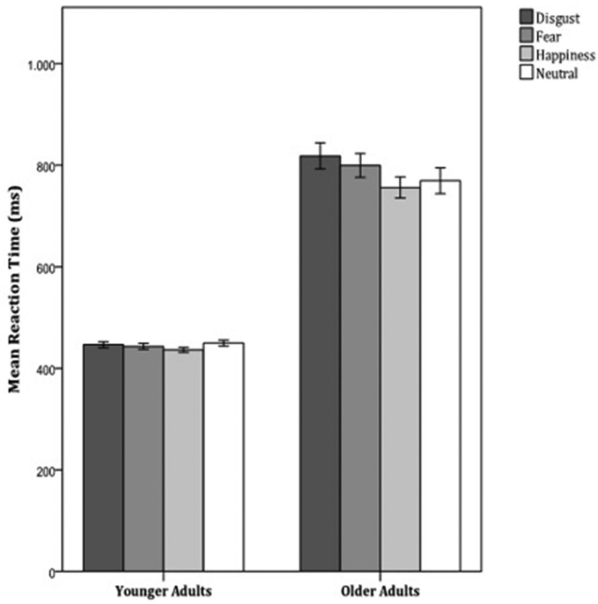

Figure 3. Line Discrimination Task for both age groups.

Self-Relevance Ratings

A 4 (emotion category) × 2 (age) mixed ANOVA on mean ratings revealed a significant main effect of age, F (1, 67) = 28.155, p < .001, η_p^2 = .296: Older adults rated all pictures as more important or self-relevant (M= 4.41, SE = .16) compared to younger adults (M= 3.35, SE = .12). Main effect of emotion category was also significant, F (1.8, 118.5) = 52.86, p < .001, η_p^2 = .441: Happy photos (M= 5.10, SE = .12) were rated with highest self-relevance, whereas disgust-related photos (M= 2.85, SE = .17) were rated with lowest self-relevance compared to items in any other emotion category, all p's < .001. However, self-relevance of fearful (M= 3.88, SE = .17) and neutral photos (M= 3.70, SE = .13) did not differ, p = 1.0 Yet, the interaction between age and emotion category was not significant, p= .31. The results were corrected and reported with Greenhouse-Geisser sphericity.

Questionnaires

We compared time perception of younger vs. older adults using their responses on the Future Time Perspective Scale. An independent-samples t-test revealed that older (M = 39.48, SE = 2.36) and younger (M = 43.16, SE = 1.49) adults in our sample did not differ in terms of time perception, t (66) = 1.39, p= .17.

Participants' global emotional experiences for the past 2 weeks were assessed via the list of emotional items. The results seem to be consistent with previous research: older adults experienced happiness (M = 3.68, SE = .11) more than younger adults (M = 3.24, SE = .12), t (67) = −2.45, p = .02. Similarly, older adults experienced serenity, which a positive emotion, (M = 3.49, SE = .16) more than younger adults (M = 2.96, SE = .15), t (67) = −2.32, p= .02. In addition, older adults reported attention (M= 3.67, SE = .17) more than younger adults (M = 2.92 SE = .14),

t (67) = −3.34, p= .001. Younger adults reported higher disgust (M= .22, SE = .03) compared to older adults (M= .02, SE = .01), t (51.6) = 5.3, p< .001.[2] Younger adults reported higher anger (M = 2.59, SE = .18) compared to older adults (M = 1.87, SE = .14), t (66) = 3.15, p = .002, but sadness, surprise, and fear experiences did not differ, all p's > .05.

Discussion

The present study investigated the effects of discrete emotional stimuli (fear, disgust, and happiness) on recognition memory in younger versus older adults. As predicted, the results replicated the disgust advantage in recognition memory for younger adults, yet this advantage disappeared with older age. Albeit no enhancement in memory accuracy, disgust-related stimuli led to a more liberal bias for older adults. Contrary to our expectations, age-related improvement in memory accuracy was not found for fear- or happiness-related stimuli.

Recognition Memory: Accuracy and Response Bias

In this study, younger adults recognized disgust-related pictures more accurately than fearful, happy or neutral pictures; however, accuracy did not differ across other emotion categories. This finding replicates previous research reporting a disgust advantage in memory (Chapman et al., 2013; Charash & McKay, 2002; Croucher et al., 2011; Kapucu & Rotello, revision submitted). Another result consistent with previous studies was that younger adults showed a more liberal response bias to negative compared to positive or neutral stimuli (Dougal & Rotello, 2007; Kapucu et al., 2008; White et al., 2014). However, disgust- and fear-related photos did not differ in terms of response bias. In addition, disgust advantage in recognition memory could not be attributed to enhanced attentional capture by disgust-related stimuli. This finding differed from that of Chapman et al. (2013) because in the current study, regardless of their specific emotion category, all stimuli captured younger adults' attention similarly in the line discrimination task.

These results replicated disgust-enhanced recognition accuracy in younger adults and showed that this enhancement was independent of participants' response biases or attentional processes. The advantage of disgust over fear for younger adults was previously explained by disgust signalling contamination and disease (Rozin & Fallon, 1987; Rozin, Haidt, & McCauley, 2000), whereas fear signalling immediate threat (Tybur, Lieberman, Kurzban, & DeScioli, 2013). There is also a potential threat related to disgusting stimuli, yet the exploration of the source of this threat is less costly for disgust-related stimuli than for fear-related stimuli (Carretié, Ruiz-Padial, López-Martín, & Albert, 2011). Disgust-related stimuli do not need to be responded as quickly as those related to fear (Krusemark & Li, 2011; Xu et al., 2016). For these reasons, younger adults specifically remember disgust-related stimuli to avoid contamination as a potential threat (Fernandes, Pandeirada, Soares, & Nairne, 2017).

The present study found that the disgust advantage in recognition memory decreased with age. Although older adults responded more liberally to disgust-related photos compared to fearful, happy or neutral ones, this response bias shift did not translate to enhanced memory performance; they remembered disgust-related stimuli no better than fearful, happy, or neutral stimuli. This finding is consistent with that of Kapucu et al. (2008) who also reported increased liberal bias to both positive and negative items in the absence of enhanced recognition accuracy in older adults.

This result could be accounted for by older adults' decreased sensitivity to disgust due to greater exposure to disgust-related situations in their lives compared to younger adults. Consistent with this explanation, older participants reported experiencing less disgust than younger adults in the current study. Decreased disgust experience may be accompanied by changes in other cognitive processes such as recognition memory. A possible explanation for these results may be the age-related decrease in activity in the insula region (see Mather, 2016, for a review; Onoda, Ishihara, & Yamaguchi, 2012). fMRI studies point out to a decreasing connectivity of the insula, especially right anterior insula, compared to other lobes (65–85 years in Muller, Mérillat, & Jäncke, 2016; 18–85 years in Vieira, Rondinoni, & Salmon, 2020) and in voxel-based morphometric (VBM) studies, bilateral insula gray matter concentration is decreased with age (17–79 years in Good et al., 2001; 20–80 years in Takahashi, Ishii, Kakigi, & Yokoyama, 2011). Insula has been associated with several functions such as emotion, motivation, pain, risk-taking, etc. (Wager & Barrett, 2017; Xue, Lu, Levin, & Bechara, 2010). Some researchers, however, emphasized the insula as an important neural substrate for disgust (Chapman & Anderson, 2012; Phillips et al., 1997; Wicker et al., 2003) and their findings indicated that the anterior insula significantly responded to contamination-related pictures in younger adults (Wright, He, Shapira, Goodman, & Liu, 2004). Therefore, age-related changes in insula could partially be responsible for the decline in disgust experience and the absence of disgust advantage in memory of older adults.

Because previous studies indicated that older adults could experience fear more than younger adults due to the loss of physical health (Teachman & Gordon, 2009), we originally predicted that older, but not younger, adults would remember fear-related pictures better than disgust-related pictures. To test this prediction, in our pilot study, we attempted to include specifically illness- or death-related images in the fear category, however, our older sample rated these pictures as eliciting sadness rather than fear. Therefore, we did not include these stimuli; hence, this original prediction of a fear advantage in older adults could not be tested. Future studies should examine the effects of different themes of fear such as illness or death on ageing memory with properly selected stimuli. In the present study, we used different stimuli for the two age groups (for details, see the Appendix) because some researchers reported that the older adults experienced mixed emotions rather than discrete emotional experiences (both positive and negative or more than one negative discrete emotion occurred simultaneously) (Carstensen et al., 2011; Charles, 2005). Therefore, in older adults, we specifically selected those stimuli that elicited the target emotion more discretely and intensely.

In the current study, the fear- and disgust-related stimuli, though were matched on arousal, were not matched on valence for younger adults: disgust-related photos were rated more negative than fear-related ones. Therefore, the disgust advantage in younger adults' recognition memory could be due to differences in valence, rather than to a specific effect of disgust. However, participants come from different groups for recognition memory processes and ratings on valence. In addition, several studies have shown that there was disgust advantage compared to fear in memory even if stimuli were matched for valence and arousal (Chapman et al., 2013; Ferré et al., 2018).

Positivity Effect

The current study did not specifically focus on the age-related positivity effect in memory. However, the effects of positive stimuli on cognitive processes are an important line of research in the ageing literature. We did not find an advantage of happiness-related items in recognition of memory over negative (disgust or fear) or neutral ones in older adults. This finding matched those observed in earlier studies. Yet, previous research showed that the age-related positivity effect was not observed when there is an experimental constraint in instructions (e.g. Grühn, Smith, & Baltes, 2005), attention (e.g., Allen, Lien, & Jardin, 2017; Joubert, Davidson, & Chainay, 2018; Mather & Knight, 2005) and cognitive resources (see Reed et al., 2014; for a review). In older adults, when task difficulty increases, the limited resources are no longer sufficient for emotion regulation and therefore processing of positive information decreases (Knight et al., 2007; Mather & Knight, 2005). The line discrimination task (Chapman et al., 2013) used to assess attention in our experiment might have served as a divided attention task that required the allocation of attention during stimuli presentation, therefore limiting the cognitive resources for emotion regulation and potentially hindering the positivity effect.The lack of a positivity effect could also be due to time perception of older adults in our sample. According to SST (Carstensen, 2006), older adults prioritize positive stimuli over negative or neutral ones because they perceive their time as limited and are motivated toward emotionally meaningful goals due to their increased emotion regulation abilities. In contrast, younger adults perceive time as expanded and are motivated to acquire new information (knowledge-related goals rather than emotional), and prioritize future goals (Fung & Carstensen, 2006). Studies, however, showed that when time perception was manipulated, the positivity effect occurred with perceived limited time (terror attack, terminal illness, etc.) regardless of chronological age (Barber, Opitz, Martins, Sakaki & Mather, 2016, but also see Kellough & Knight, 2012). In addition, when older participants perceived time as expanded, the positivity effect decreased or the knowledge-related information was prioritized compared to their counterparts (Fung & Carstensen, 2003; Kellough & Knight, 2012; Williams & Drolet, 2005). Similarly, older participants in our sample did not differ from younger participants in terms of time perception as both age groups seem to have an expanded time perception; this could be one of the reasons for the lack of a memory advantage of positive stimuli in our ageing sample.

Self-Relevance Ratings

We examined the effects of self-relevance of stimuli on memory of both younger and older adults. Happiness-related photos were rated with highest self-relevance compared to other stimuli by both age groups. Similarly, previous studies found that positive stimuli were reported to be more personally important than negative or neutral stimuli (Tomaszczyk et al., 2008). In contrast to previous findings (Montagrin et al., 2013; Tomaszczyk et al., 2008), however, self-relevance did not affect memory performance in the current study. Happiness-related photos rated with highest self-relevance were not recognized better than other items in neither age group. Surprisingly, disgust-related pictures were rated with lowest self-relevance, yet younger adults recognized disgust-related stimuli better than other stimuli. Results pointed out to a reporting bias for positive stimuli in self-relevance ratings.

Conclusion

The main purpose of the present study was to determine whether the disgust advantage in recognition memory in younger adults could also be generalized to older adults. Our results suggested that the effect of disgust-related stimuli on recognition memory may decrease with age. This research supports the idea that emotion effects cannot solely be accounted for by the arousal/valence approach. Future research should, therefore, concentrate on the investigation of discrete emotion effects on ageing and memory processes.

Notes

1. All post-hoc comparisons were done using the Bonferroni correction.
2. For older adults, disgust experience distributions were not normal and the assumption of homogeneity of variance was violated. Results were reported with log10 transformation and equal variances was not assumed for the independent t-test.

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Appendix

Emotional Experience Ratings

Repeated measures ANOVA was used to examine the intensity of emotional experience elicited by the photographs. According to the results, all selected photos elicited one specific emotion consistent with the emotion category they belonged to. For disgust-related photos, younger adults experienced more intense disgust (M = 5.93) compared to other emotions, all p's <.001 (M_{fear} = 1.32, $M_{happiness}$ =.25, $M_{sadness}$ = 1.28, M_{anger} = 1.33, $M_{surprise}$ = 1.51), F (2.73, 79.32) = 194.5, MSE = 1.14, p <.001, η_p^2 =.87. For fear related photos, there were significant differences between emotional experience ratings of fear and other emotions, F (2.92, 84.61) = 45.65, MSE = 1.95, p <.001, η_p^2 =.61. The experience of fear was rated higher (M = 4.46) than other emotions, all p's <.001 ($M_{disgust}$ = 2.00, $M_{happiness}$ =.42, $M_{sadness}$ = 2.79, M_{anger} = 2.22, $M_{surprise}$ = 1.99). Happiness differed from other emotions in terms of emotional experience evoked by happiness-related photos, F (2.10, 41.94) = 463.17, MSE =.59, p <.001, η_p^2 =.96. Happiness was significantly most experienced emotion for happiness-related stimuli (M = 6.08), all p's <.001 ($M_{disgust}$ =.04, M_{fear} =.33, $M_{sadness}$ =.74, M_{anger} =.11, $M_{surprise}$ = 1.08).

As with younger adults, there were significant differences between older adults' experience of disgust and other emotions for selected disgust-related images, F (3.31, 89.39) = 72.32, MSE = 1.80, p <.001, η_p^2 =.73. Disgust experience (M = 5.59) had higher ratings compared to other emotion categories (M_{fear} = 1.83, $M_{happiness}$ =.22, $M_{sadness}$ = 2.36 M_{anger} = 1.98, $M_{surprise}$ = 2.51), all p's <.001. For fear-related photos, older adults experienced fear (M = 4.98) more than other emotions ($M_{disgust}$ = 1.73, $M_{happiness}$ =.13, $M_{sadness}$ = 3.33, M_{anger} = 2.49, $M_{surprise}$ = 2.92), all p's <.05, F (2.38, 66.69) = 42.01, MSE = 3.82, p <.001, η_p^2 =.60. Happiness-related stimuli evoked happiness (M = 6.36) more than all other emotions ($M_{disgust}$ =.09, M_{fear} =.23, $M_{sadness}$ =.13, M_{anger} =.04, $M_{surprise}$ =.70), all p's <.001, F (2.42, 70.06) = 621.26, MSE =.63, p <.001, η_p^2 =.96.

Valence Ratings

Repeated measures ANOVA was used to assess valence ratings. For younger adults, there were significant differences across emotions, F (3, 84) = 603.198, MSE = 0.36, p <.001, η_p^2 =.96. Happiness-related photos (M = 7.72) received highest ratings on mean valence followed by neutral photos (M = 5.36). Fear- (M = 2.41) and disgust-related (M = 1.82) stimuli were rated more negative than happiness-related and neutral ones but the valence scores of disgust- and fear-related stimuli could not be matched, p=. 003. Younger participants rated disgust-related photos as more negative than fear-related photos, all p's <.001.

For older adults, there were significant differences across emotion categories in terms of valence ratings, F (3, 81) = 291.098, MSE = 0.66, p <.001, η_p^2 =.92. Older adults rated happiness-related photos the most positive (M = 7.63), followed by the neutral photos (M = 3.38), all p's <.001. Disgust- (M = 2.06) and fear-related (M = 2.13) photos were perceived as the most negative categories and they did not differ significantly on mean valence, p = 1.0.

Arousal Ratings

For younger adults, there were significant difference across emotions, F (2.04, 55.11) = 89.29, MSE = 0.73, p <.001, η_p^2 =.77. Younger adults rated negative photos (fear and disgust) the most arousing among all emotion categories, all p's <.001. Disgust- (M = 6.22) and fear-related (M = 6.23) photos were matched on arousal, p = 1.0. Happiness-related photos (M = 4.50) had higher arousal ratings than neutral (M = 3.73) ones, p <.001.

For older adults, there were again significant differences across emotion categories in terms of arousal ratings, F (3, 84) = 30.341, MSE = 0.74, p <.001, η_p^2 =.52. Older adults rated happiness-related photos (M = 4.01) as the least arousing compared to other categories, all p's <.05. Disgust- (M = 5.42) and fear-related images (M = 5.78) did not differ significantly on mean arousal, p =.67. Neutral photos (M = 5.94) had higher arousal scores than disgust-related photos, p =.03 but did not differ from fear-related photos, p = 1.0.