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Angry Faces Get Noticed Quickly: Threat Detection is not Impaired Among Older Adults

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Previous studies have found that younger adults detect threatening stimuli more quickly than other types of stimuli. This study examined whether older adults also show this adaptive threat-detection advantage. On each trial in the experiment, participants saw an array consisting of nine schematic faces. Eight of the faces were neutral; the ninth was neutral, angry, happy, or sad. Participants indicated whether there was a discrepant face in each array. Both older and younger adults were significantly faster to correctly detect a discrepant face when it signaled threat than when it signaled happiness or sadness. There was no age difference in this threat-detection advantage, indicating that this automatic process is maintained among older adults.

EMOTIONAL goals seem to influence encoding and retrieval more for older adults than for younger adults (for reviews see Carstensen, Mikels, & Mather, in press; M. Knight & Mather, in press; Mather, 2004; Mather & Carstensen, 2005). For instance, older adults distort memories in a more positive direction than younger adults do, but researchers can eliminate this age difference by asking participants to focus on their emotions, in which case both older and younger adults show positivity biases (Kennedy, Mather, & Carstensen, 2004; Mather & Johnson, 2000). Age by valence interactions in which older adults show more of a bias than do younger adults to forget negative and remember positive information are seen in memory for pictures, faces, and words (Charles, Mather, & Carstensen, 2003; B. G. Knight, Maines, & Robinson, 2002; Leigland, Schulz, & Janowsky, 2004; Mather & Carstensen, 2003; Mather & Knight, 2005). However, these interactions appear to be less likely to occur when participants are asked to make valence or arousal ratings at encoding, which may reduce the likelihood that emotion-regulation strategies such as selective attention can be effective (Comblain, D'Argembeau, Van der Linden, & Aldenhoff, 2004; Denburg, Buchanan, Tranel, & Adolphs, 2003; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002). When presented with multiple stimuli, older adults allocate less of their attention than younger adults do to negative information rather than to neutral or positive information (Mather & Carstensen, 2003; Mather, Knight, & McCaffrey, 2005; Rosler et al., 2005).

There is some evidence that older adults' positivity effects are due to strategic processing (Mather & Knight, 2005). In one experiment, older adults who did better on tests measuring cognitive control abilities were more likely to show positivity effects when recalling pictures than those who did worse. In another experiment, distracting participants with a sound discrimination task while they viewed a picture show eliminated older adults' positivity effect when later remembering the pictures. Thus, cognitive resources seem to help older adults to preferentially encode positive instead of negative information.

However, an alternative possibility is that mechanisms that detect and monitor negative information become less effective with age. Older adults may notice threatening information less quickly and pay less attention to it, leading them to remember it less well later. In general, younger adults detect threatening faces in an array of other stimuli more quickly than sad or happy faces (for a review, see Vuilleumier, 2002). The enhanced ability to detect threatening information appears to be mediated by the amygdala (Davis & Whalen, 2001).

If older adults' decreased memory for and attention to negative information is due to deterioration in processes specialized in detecting threatening information, then they should show decreases in the detection advantage seen for threatening stimuli. To test this hypothesis, we used a visual search task in which participants indicate whether there are any discrepant faces in an array of schematic faces (Öhman, Lundqvist, & Esteves, 2001). Younger adults detect discrepant angry faces more quickly than other types of emotional faces in this task (Öhman et al.). We examined whether older adults would also show this advantage. Older and younger adults differ in their peak time of day in terms of cognitive performance (for a review, see Yoon, May, & Hasher, 1999); we controlled for time-of-day effects by randomly assigning each participant to either a morning (8–11 AM) or an afternoon (12–5 PM) session.

METHODS

Participants

We recruited all of the older adults and some of the younger adults through flyers, radio announcements, and newspaper announcements; they participated in exchange for payment (see Table 1 for demographics). All older individuals were community dwelling and successfully completed a phone interview designed to screen for dementia. Some of the younger adults were students at University of California, Santa Cruz and received course credit for their participation. Older adults had completed more years of education than had younger adults, and, as is typical, older adults had higher vocabulary scores than did younger adults (Verhaeghen, 2003). In addition, as we expected, older adults were more likely than younger adults to be morning types (Yoon et al., 1999) and to be experiencing positive affect (e.g., Mroczek, 2001).

Table 1. Demographic Characteristics of the Younger and Older Adults in Experiments 1 and 2

Variable	Younger	Older
Age range	18–28	65–82
Mean age, in years	20.3 (3.0)	72.5 (4.7)*
Years of education	14.6 (2.3)	16.5 (2.9)*
Vocabulary[a]	15.0 (3.5)	21.1 (2.9)*
Morningness score[b]	43.4 (8.2)	65.5 (7.0)*
Positive affect[c]	27.6 (5.2)	37.6 (5.8)*
Negative affect[c]	13.2 (5.3)	11.5 (2.6)*
Male, female (*N*)	9, 24	11, 24

Note: Standard deviations are in parentheses.

[a]Nelson and Denny vocabulary test (Brown, Fishco, & Hanna, 1993).

[b]Horne-Ostberg Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976).

[c]Positive and negative affect scores on the Positive and Negative Affect Scale (Watson, Clark, & Tellegen, 1988).

*Younger and older adults' means differ significantly ($p < .05$) in a t test.

Materials

As in Experiment 1 by Öhman and colleagues (2001), nine schematic faces arranged in 3 × 3 matrices appeared in each trial (see Figure 1). In half of the matrices, all the faces showed the identical neutral expression. The other matrices contained eight faces with a neutral expression and one target face with an emotional expression. Participants used their right and left index fingers to press keys corresponding with yes and no responses.

Procedure

The experimenter adjusted the chair used in the experiment so that the participants' eyes were aligned with the center of the screen and their index fingers were positioned on the two response keys. The size of each individual face (3° × 3.5°) and the visual angles of the stimulus matrix on the screen (10° × 11.5°) matched those used in Experiment 1 by Öhman and colleagues (2001).

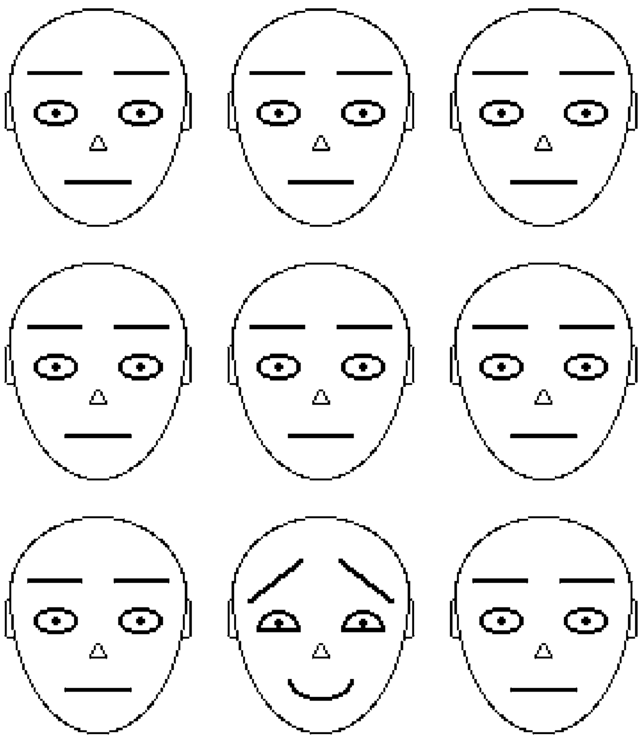

Figure 1. Example search trial, with one discrepant face.

Table 2. Accuracy and Response Times for Younger and Older Adults

Face Type	Younger	Older
Percentage correct		
Angry	98.88 (.00)	99.05 (.00)
Happy	98.10 (.01)	98.51 (.00)
Sad	97.98 (.01)	98.73 (.01)
Target absent	98.62 (.00)	99.72 (.00)
Reaction time		
Angry	652.63 (19.54)	860.92 (37.59)
Happy	692.93 (20.77)	920.97 (38.66)
Sad	670.52 (19.49)	902.60 (39.71)
Target absent	853.58 (33.14)	1701.81 (156.39)

Note: Standard errors are in parentheses.

In addition to providing written instructions, the experimenter also described the task verbally, using printouts with example matrices. The experimenter asked participants to indicate whether or not there was a discrepant face in each matrix of faces as quickly and accurately as possible by using their right and left index fingers for target-present and target-absent trials, respectively. Before the experimental trials, participants completed practice trials.

Each trial began with a central fixation cross for 2,000 ms followed by the face matrix. Each trial was terminated by a response and followed by the reappearance of the cross to begin a new trial. Threatening, sad, and friendly faces served as targets with neutral distractors. The experiment consisted of three blocks of 54 trials (totaling 162 trials). Each of the three target faces appeared in each of the nine possible positions in the matrix once. The other half of the trials consisted of matrices with nine identical neutral faces. Within each block, we randomized the presentation order.

Results

Comparing accuracy for the three target-present types of trials (angry, happy, or sad) for older and younger adults revealed no main effects of trial type or age and no interactions (all *ps* $\geq .2$; see Table 2 for means). However, older adults were more accurate than younger adults on target-absent trials, $t(66) = 3.23$, $p < .01$. We excluded the error trials as well as the trials with reaction times greater than 3 *SD* from the participant's mean (1.5% of responses) from our subsequent analyses.

To see if there was a threat-detection advantage, we compared response times for nonthreatening (happy and sad) faces with response times for threatening faces (see Table 2 for raw means) in a 2 (age: younger, older) × 2 (target expression: threatening, nonthreatening) × 2 (time of day: morning, afternoon) analysis of variance (ANOVA). Participants detected threatening faces faster (754.33 ms, $SE = 21.27$) than they did other emotional faces (794.48 ms, $SE = 21.55$), $F(1, 64) = 52.28$, $p < .001$, $\eta_p^2 = .45$. There was a marginally significant Age × Target expression interaction, $F(1, 64) = 3.44$, $p < .07$, $\eta_p^2 = .05$ (see Figure 2). To better understand this interaction, we conducted separate analyses for each age group. Younger adults were faster at detecting threatening faces ($M = 653.0$ ms, $SE = 19.9$ ms) than nonthreatening faces ($M = 682.9$, $SE = 19.7$), $F(1, 31) = 18.95$, $p < .001$, $\eta_p^2 = .38$. Older adults were also faster at detecting threatening faces ($M = 855.64$ ms, $SE = 36.77$ ms) than nonthreatening faces ($M = 906.10$, $SE = 37.49$), but they had a larger effect size than younger adults did, $F(1, 33) = 34.19$, $p < .001$, $\eta_p^2 = .51$.

Thus, if anything, older adults showed a larger threat-detection advantage than younger adults did, the opposite of what would be predicted by age-related decline in threat-detection processes. Finally, there was a marginally significant Age × Time of day interaction, with younger adults slower in the morning ($M = 676.32$ ms, $SE = 45.01$) than in the afternoon ($M = 659.56$ ms, $SE = 41.09$) but older adults faster in the morning ($M = 816.96$ ms, $SE = 43.58$) than in the afternoon ($M = 944.79$ ms, $SE = 39.99$), $F(1, 64) = 2.90$, $p = .09$, $\eta_p^2 = .04$. There were no other effects of time of day.

It is possible that angry faces are only detected faster than happy but not sad faces or only faster than sad but not happy faces. To test these possibilities, we also ran follow-up ANOVAs just comparing reaction times for angry and sad faces separately for younger and older adults as well as ANOVAs comparing reaction times for angry and happy faces. Each of these four separate ANOVAs yielded a significant effect of emotion type, indicating that detection of angry faces was faster than either detection of sad or happy faces for both younger and older adults. In addition, ANOVAs including all three types of faces (angry, sad, and happy) rather than just threat versus nonthreat (as described above) also yielded significant main effects but no Age × Target type interaction.

Raw reaction time data can be difficult to interpret when there are overall group differences such as in this experiment in which older adults were slower than younger adults. Unadjusted raw scores may appear to differ in magnitude across age but actually reflect equivalent proportional changes relative to baseline (Faust, Balota, Spieler, & Ferraro, 1999; Salthouse & Hedden, 2002). Thus, in addition to comparing raw reaction times, we used ratio scores to compare threat and nonthreat trials (e.g., Salthouse & Hedden). We divided the average reaction times for threatening and nonthreatening faces by the average reaction times for matrices with all neutral faces. On average, younger adults had larger ratios ($M = .80$, $SE = .03$) than older adults did ($M = .63$, $SE = .03$), $F(1, 64) = 12.27$, $p < .01$, $\eta_p^2 = .16$, indicating that older adults were especially slow to respond when there were no discrepant faces. This may reflect a speed–accuracy trade-off for these trials, as older adults were more accurate than younger adults on only this type of trial (see the previous discussion). As in the raw reaction time analysis, there was a main effect of target expression, $F(1, 64) = 51.86$, $p < .001$, $\eta_p^2 = .45$. Relative to the neutral baseline, participants were faster to detect the angry faces ($M = .70$, $SE = .02$) than the other emotion faces ($M = .73$, $SE = .03$). This effect did not interact with age group; $F(1, 64) = .00$, $p = .99$, $\eta_p^2 = .00$. Thus, when we used ratio scores to correct for older adults' slower overall reaction times, there was no indication of an age difference in threat detection. According to Cohen (1988), our experimental design provided substantial power to detect a large effect size for the Age × Target type interaction, with power = .9; thus it is unlikely that we failed to detect a large age difference in the threat detection advantage. We had less power to detect interactions with medium (power = .53) or small (power = .12) effect sizes.

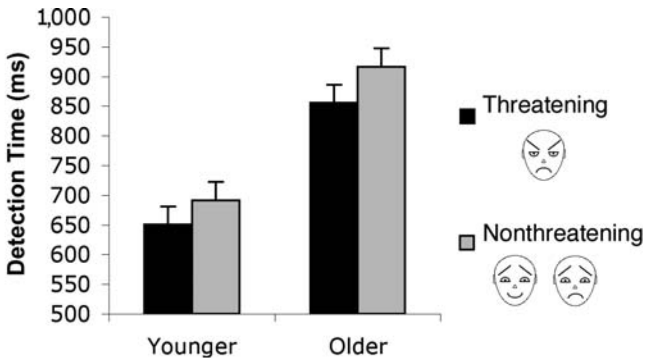

Figure 2. Younger and older adults' reaction times to detect threatening and nonthreatening faces.

Discussion

The current experiment provides information about an important piece of the puzzle in understanding the similarities and differences in younger and older adults' affective information processing, suggesting that processes enabling a quick response to dangerous stimuli do not decline with age. In this study, we found that, like younger adults, older adults detect schematic threatening faces more quickly than other types of emotional stimuli. Early detection of threatening stimuli provides a survival advantage by allowing for a rapid response (Öhman & Mineka, 2001), and it appears to be an automatic process (Öhman et al., 2001).

In contrast, when presented with multiple stimuli, older adults orient away from negative (both threatening and nonthreatening) stimuli in their attention (Mather & Carstensen, 2003; Mather et al., 2005; Rosler et al., 2005). What might explain the dissociation between the initial detection results in this study and the subsequent attention results in previous studies? Studies with younger adults reveal that the rapid alerting system for threat is an automatic response mostly inaccessible to cognitive control (Anderson, Christoff, Panitz, De Rosa, & Gabrieli, 2003; Öhman & Mineka, 2001). As such, it is unlikely to be influenced by emotion-regulation goals, unlike selective attention processes that operate after the nature of various stimuli have been discerned. Indeed, using eye tracking, Rosler and associates (2005) found that both older and younger adults initially saccade to negative arousing pictures, but that younger adults dwell longer on these pictures than older adults do.

In this study we found a marginally significant interaction of time of day and age on the overall speed of processing that is consistent with prior findings of age differences in circadian arousal (Yoon et al., 1999). However, we did not find any time-of-day effects in threat detection. This is consistent with prior findings that age differences in what time of day leads to peak performance tend to be found for strategic tasks but not for more automatic tasks (Zacks, Hasher, & Li, 2000). More generally, our finding that older adults show as much of a threat-detection advantage as younger adults do is consistent with previous findings that automatic processes are well maintained among older adults (e.g., Fleischman, Wilson, Gabrieli, Bienias, & Bennett, 2004; Jennings & Jacoby, 1993).

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