

Effects of Age on Detection of Emotional Information

Comment [e1]: Establishing a title, 2.01, Preparing the manuscript for submission, 8.02

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Author Note

Comment [a2]: Elements of an author note, 2.03

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Abstract

Comment [e3]: Writing the abstract, 2.04

Age differences were examined in affective processing, in the context of a visual search task. Young and older adults were faster to detect high arousal images compared with low arousal and neutral items. Younger adults were faster to detect positive high arousal targets compared with other categories. In contrast, older adults exhibited an overall detection advantage for emotional images compared with neutral images. Together, these findings suggest that older adults do not display valence-based effects on affective processing at relatively automatic stages.

Keywords: aging, attention, information processing, emotion, visual search

Effects of Age on Detection of Emotional Information

Frequently, people encounter situations in their environment in which it is impossible to attend to all available stimuli. It is therefore of great importance for one's attentional processes to select only the most salient information in the environment to which one should attend. Previous research has suggested that emotional information is privy to attentional selection in young adults (e.g., Anderson, 2005; Calvo & Lang, 2004; Carretie, Hinojosa, Marin-Loeches, Mecado & Tapia, 2004; Nummenmaa, Hyona, & Calvo, 2006), an obvious service to evolutionary drives to approach rewarding situations and to avoid threat and danger (Davis & Whalen, 2001; Dolan & Vuilleumier, 2003; Lang, Bradley, & Cuthbert, 1997; LeDoux, 1995).

Comment [e4]: Writing the introduction, 2.05

Comment [a5]: Ordering citations within the same parentheses, 6.16

For example, Ohman, Flykt, and Esteves (2001) presented participants with 3×3 visual arrays with images representing four categories (snakes, spiders, flowers, mushrooms). In half the arrays, all nine images were from the same category, whereas in the remaining half of the arrays, eight images were from one category and one image was from a different category (e.g., 8 flowers and 1 snake). Participants were asked to indicate whether the matrix included a discrepant stimulus. Results indicated that fear-relevant images were more quickly detected than fear-irrelevant items, and larger search facilitation effects were observed for participants who were fearful of the stimuli. A similar pattern of results has been observed when examining the attention-grabbing nature of negative facial expressions, with threatening faces (including those not attended to) identified more quickly than positive or neutral faces (Eastwood, Smilek, & Merikle, 2001; Hansen & Hansen, 1988). The enhanced detection of emotional information is not limited to threatening stimuli; there is evidence that any high-arousing stimulus can be detected rapidly, regardless of whether it is positively or negatively valenced (Anderson, 2005;

Comment [a6]: Selecting the correct tense, 3.18

Comment [e7]: Numbers that represent statistical or mathematical functions, 4.31

Comment [e8]: Numbers expressed in words, 4.32

Comment [e9]: Use of hyphenation for compound words, 4.13, Table 4.1

Calvo & Lang, 2004; Carretie et al., 2004; Juth, Lundqvist, Karlsson, & Ohman, 2005; Nummenmaa et al., 2006).

From this research, it seems clear that younger adults show detection benefits for arousing information in the environment. It is less clear whether these effects are preserved across the adult life span. The focus of the current research is on determining the extent to which aging influences the early, relatively automatic detection of emotional information.

Comment [e10]: Continuity in presentation of ideas, 3.05

Regions of the brain thought to be important for emotional detection remain relatively intact with aging (reviewed by Chow & Cummings, 2000). Thus, it is plausible that the detection of emotional information remains relatively stable as adults age. However, despite the preservation of emotion-processing regions with age (or perhaps because of the contrast between the preservation of these regions and age-related declines in cognitive-processing regions; Good et al., 2001; Hedden & Gabrieli, 2004; Ohnishi, Matsuda, Tabira, Asada, & Uno, 2001; Raz, 2000; West, 1996), recent behavioral research has revealed changes that occur with aging in the regulation and processing of emotion. According to the socioemotional selectivity theory (Carstensen, 1992), with aging, time is perceived as increasingly limited, and as a result, emotion regulation becomes a primary goal (Carstensen, Isaacowitz, & Charles, 1999). According to socioemotional selectivity theory, age is associated with an increased motivation to derive emotional meaning from life and a simultaneous decreasing motivation to expand one's knowledge base. As a consequence of these motivational shifts, emotional aspects of the environment become more salient and the frequency with which emotion regulation goals are activated increases (Carstensen, Fung & Charles, 2003), causing a shift in focus to emotional aspects of information. Thus, older adults may actually show a greater detection of emotional information in their environment than do young adults.

Comment [a11]: Citing one work by six or more authors, 6.12

Comment [a12]: No capitalization in naming theories, 4.16

To maintain positive affect in the face of negative age-related change (e.g., limited time remaining, physical and cognitive decline), older adults may adopt new cognitive strategies. One such strategy, discussed recently, is the positivity effect (Carstensen & Mikels, 2005), in which older adults spend proportionately more time processing positive emotional material and less time processing negative emotional material. Studies examining the influence of emotion on memory (Charles, Mather, & Carstensen, 2003; Kennedy, Mather, & Carstensen, 2004) have found that compared with younger adults, older adults recall proportionally more positive information and proportionally less negative information. Similar results have been found when examining eye-tracking patterns: Older adults looked at positive images longer than younger adults did, even when no age differences were observed in looking time for negative stimuli (Isaacowitz, Wadlinger, Goren, & Wilson, 2006). However, this positivity effect has not gone uncontested; some researchers have found evidence inconsistent with the positivity effect (e.g., Grühn, Smith, & Baltes, 2005; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002).

Comment [e13]: Using the colon between two grammatically complete clauses, 4.05

Comment [e14]: Capitalization of words beginning a sentence after a colon, 4.14

Based on this previously discussed research, three competing hypotheses exist to explain age differences in emotional processing associated with the normal aging process. First, emotional information may remain important throughout the life span, leading to similarly facilitated detection of emotional information in younger and older adults. Second, with aging, emotional information may take on additional importance, resulting in older adults' enhanced detection of emotional information in their environment. Third, older adults may focus principally on positive emotional information and may show facilitated detection of positive, but not negative, emotional information.

Comment [a15]: Hypotheses and their correspondence to research design, Introduction, 2.05

The primary goal in the present experiment was to adjudicate among these alternatives. To do so, we employed a visual search paradigm to assess young and older adults' abilities to

rapidly detect emotional information. We hypothesized that on the whole, older adults would be slower to detect information than young adults would be (consistent with Hahn, Carlson, Singer, & Gronlund, 2006; Mather & Knight, 2006); the critical question was whether the two age groups would show similar or divergent facilitation effects with regard to the effects of emotion on item detection. On the basis of the existing literature, the first two previously discussed hypotheses seemed to be more plausible than the third alternative. This is because there is reason to think that the positivity effect may be operating only at later stages of processing (e.g., strategic, elaborative, and emotion regulation processes) rather than at the earlier stages of processing involved in the rapid detection of information (see Mather & Knight, 2005, for discussion). Thus, the first two hypotheses, that emotional information maintains its importance across the life span or that emotional information in general takes on greater importance with age, seemed particularly applicable to early stages of emotional processing.

Comment [e16]: Using the semicolon to separate two independent clauses not joined by a conjunction, 4.04

Comment [e17]: Using the comma between elements in a series, 4.03

Comment [a18]: Punctuation with citations in parenthetical material, 6.21

Indeed, a couple of prior studies have provided evidence for intact early processing of emotional facial expressions with aging. Mather and Knight (2006) examined young and older adults' abilities to detect happy, sad, angry, or neutral faces presented in a complex visual array. Mather and Knight found that like younger adults, older adults detected threatening faces more quickly than they detected other types of emotional stimuli. Similarly, Hahn et al. (2006) also found no age differences in efficiency of search time when angry faces were presented in an array of neutral faces, compared with happy faces in neutral face displays. When angry faces, compared with positive and neutral faces, served as nontarget distractors in the visual search arrays, however, older adults were more efficient in searching, compared with younger adults, suggesting that older adults were better able to inhibit angry facial expressions. Although these studies included both positive and negative stimuli, it is important to note that the positive and

Comment [a19]: Citing references in text, inclusion of year within paragraph, 6.11, 6.12

Comment [e20]: Prefixes and suffixes that do not require hyphens, Table 4.2

negative stimuli were not of equivalent arousal levels (fearful faces typically are more arousing than happy faces; Hansen & Hansen, 1988). Given that arousal is thought to be a key factor in modulating the attentional focus effect (Hansen & Hansen, 1988; Pratto & John, 1991; Reimann & McNally, 1995), to more clearly understand emotional processing in the context of aging, it is necessary to include both positive and negative emotional items with equal levels of arousal.

In the current research, therefore, we compared young and older adults' detection of four categories of emotional information (positive high arousal, positive low arousal, negative high arousal, and negative low arousal) with their detection of neutral information. The positive and negative stimuli were carefully matched on arousal level, and the categories of high and low arousal were closely matched on valence to assure that the factors of valence (positive, negative) and arousal (high, low) could be investigated independently of one another. Participants were presented with a visual search task including images from these different categories (e.g., snakes, cars, teapots). For half of the multi-image arrays, all of the images were of the same item, and for the remaining half of the arrays, a single target image of a different type from the remaining items was included. Participants were asked to decide whether a different item was included in the array, and their reaction times were recorded for each decision. Of primary interest were differences in response times (RTs) based on the valence and arousal levels of the target categories. We reasoned that if young and older adults were equally focused on emotional information, then we would expect similar degrees of facilitation in the detection of emotional stimuli for the two age groups. By contrast, if older adults were more affectively focused than were younger adults, older adults should show either faster detection speeds for all of the emotional items (relative to the neutral items) than shown by young adults or greater facilitation

Comment [a21]: Prefixed words that require hyphens, Table 4.3

Comment [e22]: Using abbreviations 4.22, Explanation of abbreviations 4.23, Abbreviations used often in APA journals 4.25, Plurals of abbreviations 4.29

for the arousing items than shown by the young adults (resulting in an interaction between age and arousal).

Method

Participants

Younger adults (14 women, 10 men, $M_{\text{age}} = 19.5$ years, age range: 18–22 years) were recruited with flyers posted on the Boston College campus. Older adults (15 women, 9 men, $M_{\text{age}} = 76.1$ years, age range: 68–84 years) were recruited through the Harvard Cooperative on Aging (see Table 1, for demographics and test scores).¹ Participants were compensated \$10 per hour for their participation. There were 30 additional participants, recruited in the same way as described above, who provided pilot rating values: 5 young and 5 old participants for the assignment of items within individual categories (i.e., images depicting cats), and 10 young and 10 old participants for the assignment of images within valence and arousal categories. All participants were asked to bring corrective eyewear if needed, resulting in normal or corrected to normal vision for all participants.

Materials and Procedure

The visual search task was adapted from Ohman et al. (2001). There were 10 different types of items (2 each of five Valence \times Arousal categories: positive high arousal, positive low arousal, neutral, negative low arousal, negative high arousal), each containing nine individual exemplars that were used to construct 3×3 stimulus matrices. A total of 90 images were used, each appearing as a target and as a member of a distracting array. A total of 360 matrices were presented to each participant; half contained a target item (i.e., 8 items of one type and 1 target item of another type) and half did not (i.e., all 9 images of the same type). Within the 180 nontarget trials, the location of each item rotated twice through the nine locations in a given

Comment [e23]: Elements of the Method section, 2.06

Comment [e24]: Organizing a manuscript with levels of heading, 3.03

Comment [a25]: Identifying subsections in the Method section, 2.06

Comment [e26]: Using numerals to express numbers representing age, 4.31

Comment [a27]: Numbering and discussing tables in text, 5.05

Comment [A28]: Participant (subject) characteristics, Method, 2.06

matrix. Within the 180 target trials, each of the five emotion categories (e.g., positive high arousal, neutral, etc.) was represented in 36 trials. Further, within each of the 36 trials for each emotion category, 9 trials were created for each of the combinations with the remaining four other emotion categories (e.g., 9 trials with 8 positive high arousal items and 1 neutral item). Location of the target was randomly varied such that no target within an emotion category was presented in the same location in arrays of more than one other emotion category (i.e., a negative high arousal target appeared in a different location when presented with positive high arousal array images than when presented with neutral array images).

The items within each category of grayscale images shared the same verbal label (e.g., mushroom, snake), and the items were selected from online databases and photo clipart packages. Each image depicted a photo of the actual object. Ten pilot participants were asked to write down the name corresponding to each object; any object that did not consistently generate the intended response was eliminated from the set. For the remaining images, an additional 20 pilot participants rated the emotional valence and arousal of the objects and assessed the degree of visual similarity among objects within a set (i.e., how similar the mushrooms were to one another) and between objects across sets (i.e., how similar the mushrooms were to the snakes).

Valence and arousal ratings. Valence and arousal were judged on 7-point scales (1 = *negative valence* or *low arousal* and 7 = *positive valence* or *high arousal*). Negative objects received mean valence ratings of 2.5 or lower, neutral objects received mean valence ratings of 3.5 to 4.5, and positive objects received mean valence ratings of 5.5 or higher. High arousal objects received mean arousal ratings greater than 5, and low arousal objects (including all neutral stimuli) received mean arousal ratings of less than 4. We selected categories for which both young and older adults agreed on the valence and arousal classifications, and stimuli were

Comment [e29]: Latin abbreviations, 4.26

Comment [a30]: Numbers expressed in words at beginning of sentence, 4.32

Comment [e31]: Italicization of anchors of a scale, 4.21

selected such that the arousal difference between positive low arousal and positive high arousal was equal to the difference between negative low arousal and negative high arousal.

Similarity ratings. Each item was rated for within-category and between-categories similarity. For within-category similarity, participants were shown a set of exemplars (e.g., a set of mushrooms) and were asked to rate how similar each mushroom was to the rest of the mushrooms, on a 1 (*entirely dissimilar*) to 7 (*nearly identical*) scale. Participants made these ratings on the basis of overall similarity and on the basis of the specific visual dimensions in which the objects could differ (size, shape, orientation). Participants also rated how similar objects of one category were to objects of another category (e.g., how similar the mushrooms were to the snakes). Items were selected to assure that the categories were equated on within-category and between-categories similarity of specific visual dimensions as well as for the overall similarity of the object categories ($ps > .20$). For example, we selected particular mushrooms and particular cats so that the mushrooms were as similar to one another as were the cats (i.e., within-group similarity was held constant across the categories). Our object selection also assured that the categories differed from one another to a similar degree (e.g., that the mushrooms were as similar to the snakes as the cats were similar to the snakes).

Procedure

Each trial began with a white fixation cross presented on a black screen for 1,000 ms; the matrix was then presented, and it remained on the screen until a participant response was recorded. Participants were instructed to respond as quickly as possible with a button marked *yes* if there was a target present, or a button marked *no* if no target was present. Response latencies and accuracy for each trial were automatically recorded with E-Prime (Version 1.2) experimental

software. Before beginning the actual task, participants performed 20 practice trials to assure compliance with the task instructions.

Results

Analyses focus on participants' RTs to the 120 trials in which a target was present and was from a different emotional category from the distractor (e.g., RTs were not included for arrays containing eight images of a cat and one image of a butterfly because cats and butterflies are both positive low arousal items). RTs were analyzed for 24 trials of each target emotion category. RTs for error trials were excluded (fewer than 5% of all responses) as were RTs that were ± 3 *SD* from each participant's mean (approximately 1.5% of responses). Median RTs were then calculated for each of the five emotional target categories, collapsing across array type (see Table 2 for raw RT values for each of the two age groups). This allowed us to examine, for example, whether participants were faster to detect images of snakes than images of mushrooms, regardless of the type of array in which they were presented. Because our main interest was in examining the effects of valence and arousal on participants' target detection times, we created scores for each emotional target category that controlled for the participant's RTs to detect neutral targets (e.g., subtracting the RT to detect neutral targets from the RT to detect positive high arousal targets). These difference scores were then examined with a $2 \times 2 \times 2$ (Age [young, older] \times Valence [positive, negative] \times Arousal [high, low]) analysis of variance (ANOVA). This ANOVA revealed only a significant main effect of arousal, $F(1, 46) = 8.41$, $p = .006$, $\eta_p^2 = .16$, with larger differences between neutral and high arousal images ($M = 137$) than between neutral and low arousal images ($M = 93$; i.e., high arousal items processed more quickly across both age groups compared with low arousal items; see Figure 1). There was no significant main effect for valence, nor was there an interaction between valence and arousal. It is critical that the analysis

Comment [e32]: Results, 2.07

Comment [a33]: Symbols, 4.46; numbers, 4.31

Comment [e34]: Abbreviations accepted as words, 4.24

Comment [e35]: Nouns followed by numerals or letters, 4.17

Comment [e36]: Reporting p values, decimal fractions, 4.35

Comment [a37]: Statistical symbols, 4.46, Table 4.5

Comment [A38]: Numbering and discussing figures in text, 5.05

revealed only a main effect of age but no interactions with age. Thus, the arousal-mediated effects on detection time appeared stable in young and older adults.

The results described above suggested that there was no influence of age on the influences of emotion. To further test the validity of this hypothesis, we submitted the RTs to the five categories of targets to a 2×5 (Age [young, old] \times Target Category [positive high arousal, positive low arousal, neutral, negative low arousal, negative high arousal]) repeated measures ANOVA.² Both the age group, $F(1, 46) = 540.32, p < .001, \eta_p^2 = .92$, and the target category, $F(4, 184) = 8.98, p < .001, \eta_p^2 = .16$, main effects were significant, as well as the Age Group \times Target Category interaction, $F(4, 184) = 3.59, p = .008, \eta_p^2 = .07$. This interaction appeared to reflect the fact that for the younger adults, positive high arousal targets were detected faster than targets from all other categories, $t_s(23) < -1.90, p < .001$, with no other target categories differing significantly from one another (although there were trends for negative high arousal and negative low arousal targets to be detected more rapidly than neutral targets ($p < .12$)). For older adults, all emotional categories of targets were detected more rapidly than were neutral targets, $t_s(23) > 2.56, p < .017$, and RTs to the different emotion categories of targets did not differ significantly from one another. Thus, these results provided some evidence that older adults may show a broader advantage for detection of any type of emotional information, whereas young adults' benefit may be more narrowly restricted to only certain categories of emotional information.

Comment [e39]: Statistics in text, 4.45

Comment [e40]: Spacing, alignment, and punctuation of mathematical copy, 4.47

Comment [A41]: Capitalize effects or variables when they appear with multiplication signs, 4.20

Discussion

Comment [e42]: Elements of the discussion section, 2.08

As outlined previously, there were three plausible alternatives for young and older adults' performance on the visual search task: The two age groups could show a similar pattern of enhanced detection of emotional information, older adults could show a greater advantage for

emotional detection than young adults, or older adults could show a greater facilitation than young adults only for the detection of positive information. The results lent some support to the first two alternatives, but no evidence was found to support the third alternative.

Comment [A43]: Clear statement of support or nonsupport of hypotheses, Discussion, 2.08

In line with the first alternative, no effects of age were found when the influence of valence and arousal on target detection times was examined; both age groups showed only an arousal effect. This result is consistent with prior studies that indicated that arousing information can be detected rapidly and automatically by young adults (Anderson, Christoff, Panitz, De Rosa, & Gabrieli, 2003; Ohman & Mineka, 2001) and that older adults, like younger adults, continue to display a threat detection advantage when searching for negative facial targets in arrays of positive and neutral distractors (Hahn et al., 2006; Mather & Knight, 2006). Given the relative preservation of automatic processing with aging (Fleischman, Wilson, Gabrieli, Bienias, & Bennett, 2004; Jennings & Jacoby, 1993), it makes sense that older adults would remain able to take advantage of these automatic alerting systems for detecting high arousal information.

However, despite the similarity in arousal-mediated effects on detection between the two age groups, the present study did provide some evidence for age-related change (specifically, age-related enhancement) in the detection of emotional information. When examining RTs for the five categories of emotional targets, younger adults were more efficient in detecting positive high arousal images (as presented in Table 2), whereas older adults displayed an overall advantage for detecting all emotional images compared with neutral images. This pattern suggests a broader influence of emotion on older adults' detection of stimuli, providing support for the hypothesis that as individuals age, emotional information becomes more salient.

It is interesting that this second set of findings is clearly inconsistent with the hypothesis that the positivity effect in older adults operates at relatively automatic stages of information

processing, given that no effects of valence were observed in older adults' detection speed. In the present study, older adults were equally fast to detect positive and negative information, consistent with prior research that indicated that older adults often attend equally to positive and negative stimuli (Rosler et al., 2005). Although the pattern of results for the young adults has differed across studies—in the present study and in some past research, young adults have shown facilitated detection of positive information (e.g., Anderson, 2005; Calvo & Lang, 2004; Carretie et al., 2004; Juth et al., 2005; Nummenmaa et al., 2006), whereas in other studies, young adults have shown an advantage for negative information (e.g., Armony & Dolan, 2002; Hansen & Hansen, 1988; Mogg, Bradley, de Bono, & Painter, 1997; Pratto & John, 1991; Reimann & McNally, 1995; Williams, Mathews, & MacLeod, 1996)—what is important to note is that the older adults detected both positive and negative stimuli at equal rates. This equivalent detection of positive and negative information provides evidence that older adults display an advantage for the detection of emotional information that is not valence-specific.

Thus, although younger and older adults exhibited somewhat divergent patterns of emotional detection on a task reliant on early, relatively automatic stages of processing, we found no evidence of an age-related positivity effect. The lack of a positivity focus in the older adults is in keeping with the proposal (e.g., Mather & Knight, 2006) that the positivity effect does not arise through automatic attentional influences. Rather, when this effect is observed in older adults, it is likely due to age-related changes in emotion regulation goals that operate at later stages of processing (i.e., during consciously controlled processing), once information has been attended to and once the emotional nature of the stimulus has been discerned.

Although we cannot conclusively say that the current task relies strictly on automatic processes, there are two lines of evidence suggesting that the construct examined in the current

Comment [e44]: Use of an em dash to indicate an interruption in the continuity of a sentence, 4.06; Description of an em dash, 4.13

research examines relatively automatic processing. First, in their previous work, Ohman et al. (2001) compared RTs with both 2×2 and 3×3 arrays. No significant RT differences based on the number of images presented in the arrays were found. Second, in both Ohman et al.'s (2001) study and the present study, analyses were performed to examine the influence of target location on RT. Across both studies, and across both age groups in the current work, emotional targets were detected more quickly than were neutral targets, regardless of their location. Together, these findings suggest that task performance is dependent on relatively automatic detection processes rather than on controlled search processes.

Comment [A45]: Use of parallel construction with coordinating conjunctions used in pairs, 3.23

Although further work is required to gain a more complete understanding of the age-related changes in the early processing of emotional information, our findings indicate that young and older adults are similar in their early detection of emotional images. The current study provides further evidence that mechanisms associated with relatively automatic processing of emotional images are well maintained throughout the latter portion of the life span (Fleischman et al., 2004; Jennings & Jacoby, 1993; Leclerc & Hess, 2005). It is critical that, although there is evidence for a positive focus in older adults' controlled processing of emotional information (e.g., Carstensen & Mikels, 2005; Charles et al., 2003; Mather & Knight, 2005), the present results suggest that the tendency to focus on the positive does not always arise when tasks require relatively automatic and rapid detection of information in the environment.

Comment [A46]: Discussion section ending with comments on importance of findings, 2.08

References

Comment [e47]: Construction of an accurate and complete reference list, 6.22; General description of references, 2.11

Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness.

Journal of Experimental Psychology: General, *154*, 258–281. doi:10.1037/0096-3445.134.2.258

Comment [a48]: Digital object identifier as article identifier, 6.31; Examples of references to periodicals, 7.01

Anderson, A. K., Christoff, K., Panitz, D., De Rosa, E., & Gabrieli, J. D. E. (2003). Neural correlates of the automatic processing of threat facial signals. *Journal of Neuroscience*, *23*, 5627–5633.

Armony, J. L., & Dolan, R. J. (2002). Modulation of spatial attention by fear-conditioned stimuli: An event-related fMRI study. *Neuropsychologia*, *40*, 817–826. doi:10.1016/S0028-3932%2801%2900178-6

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology*, *56*, 893–897. doi:10.1037/0022-006X.56.6.893

Calvo, M. G., & Lang, P. J. (2004). Gaze patterns when looking at emotional pictures: Motivationally biased attention. *Motivation and Emotion*, *28*, 221–243. doi:10.1023/B%3AMOEM.0000040153.26156.ed

Carrette, L. Hinojosa, J. A., Martin-Loeches, M., Mecado, F., & Tapia, M. (2004). Automatic attention to emotional stimuli: Neural correlates. *Human Brain Mapping*, *22*, 290–299. doi:10.1002/hbm.20037

Carstensen, L. L. (1992). Social and emotional patterns in adulthood: Support for socioemotional selectivity theory. *Psychology and Aging*, *7*, 331–338. doi: 10.1037/0882-7974.7.3.331

Carstensen, L. L., Fung, H., & Charles, S. (2003). Socioemotional selectivity theory and the regulation of emotion in the second half of life. *Motivation and Emotion*, *27*, 103–123.

- Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychology, 54*, 165–181. doi: 10.1023/A%3A1024569803230
- Carstensen, L. L., & Mikels, J. A. (2005). At the intersection of emotion and cognition: Aging and the positivity effect. *Current Directions in Psychological Science, 14*, 117–121. doi: 10.1111/j.0963-7214.2005.00348.x
- Charles, S. T., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: The forgettable nature of negative images for older adults. *Journal of Experimental Psychology: General, 132*, 310–324. doi: 10.1037/0096-3445.132.2.310
- Chow, T. W., & Cummings, J. L. (2000). The amygdala and Alzheimer's disease. In J. P. Aggleton (Ed.), *The amygdala: A functional analysis* (pp. 656–680). Oxford, England: Oxford University Press.
- Davis, M., & Whalen, P. J. (2001). The amygdala: Vigilance and emotion. *Molecular Psychiatry, 6*, 13–34. doi: 10.1038/sj.mp.4000812
- Dolan, R. J., & Vuilleumier, P. (2003). Amygdala automaticity in emotional processing. *Annals of the New York Academy of Sciences, 985*, 348–355.
- Eastwood, J. D., Smilek, D., & Merikle, P. M. (2001). Negative facial expression captures attention and disrupts performance. *Perceptual Physiology, 65*, 352–358.
- Fleischman, D. A., Wilson, R. S., Gabrieli, J. D. E., Bienias, J. L., & Bennett, D. A. (2004). A longitudinal study of implicit and explicit memory in old persons. *Psychology and Aging, 19*, 617–625. doi: 10.1037/0882-7974.19.4.617

- Good, C. D., Johnsrude, I. S., Ashburner, J., Henson, R. N. A., Firston, K. J., & Frackowiak, R. S. J. (2001). A voxel-based morphometric study of ageing in 465 normal adult human brains. *NeuroImage*, *14*, 21–36. doi:10.1006/nimg.2001.0786
- Grühn, D., Smith, J., & Baltes, P. B. (2005). No aging bias favoring memory for positive material: Evidence from a heterogeneity-homogeneity list paradigm using emotionally toned words. *Psychology and Aging*, *20*, 579–588. doi: 10.1037/0882-7974.20.4.579
- Hahn, S., Carlson, C., Singer, S., & Gronlund, S. D. (2006). Aging and visual search: Automatic and controlled attentional bias to threat faces. *Acta Psychologica*, *123*, 312–336. doi: 10.1016/j.actpsy.2006.01.008
- Hansen, C. H., & Hansen, R. D. (1988). Finding the face in the crowd: An anger superiority effect. *Journal of Personality and Social Psychology*, *54*, 917–924. doi: 10.1037/0022-3514.54.6.917
- Hedden, T., & Gabrieli, J. D. E. (2004). Insights into the ageing mind: A view from cognitive neuroscience. *Nature Reviews Neuroscience*, *5*, 87–96. doi:10.1038/nrn1323
- Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006). Selective preference in visual fixation away from negative images in old age? An eye-tracking study. *Psychology of Aging*, *21*, 40–48. doi:10.1037/0882-7974.21.1.40
- Jennings, J. M., & Jacoby, L. L. (1993). Automatic versus intentional uses of memory: Aging, attention, and control. *Psychology and Aging*, *8*, 283–293. doi:10.1037/0882-7974.8.2.283
- Juth, P., Lundqvist, D., Karlsson, A., & Ohman, A. (2005). Looking for foes and friends: Perceptual and emotional factors when finding a face in the crowd. *Emotion*, *5*, 379–395. doi:10.1037/1528-3542.5.4.379

Kennedy, Q., Mather, M., & Carstensen, L. L. (2004). The role of motivation in the age-related positive bias in autobiographical memory. *Psychological Science, 15*, 208–214.

doi:10.1111/j.0956-7976.2004.01503011.x

Kensinger, E. A., Brierley, B., Medford, N., Growdon, J. H., & Corkin, S. (2002). Effects of normal aging and Alzheimer's disease on emotional memory. *Emotion, 2*, 118–134. doi: 10.1037/1528-3542.2.2.118

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). Motivated attention: Affect, activation, and action. In P. J. Lang, R. F. Simons, & M. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes* (pp. 97–135). Mahwah, NJ: Erlbaum.

Comment [A49]: Example of reference to a book chapter, print version, no DOI, 7.02, Example 25

Leclerc, C. M., & Hess, T. M. (2005, August). *Age differences in processing of affectively primed information*. Poster session presented at the 113th Annual Convention of the American Psychological Association, Washington, DC.

LeDoux, J. E. (1995). Emotion: Clues from the brain. *Annual Review of Psychology, 46*, 209–235. doi:10.1146/annurev.ps.46.020195.001233

Mather, M., & Knight, M. (2005). Goal-directed memory: The role of cognitive control in older adults' emotional memory. *Psychology and Aging, 20*, 554–570. doi: 10.1037/0882-7974.20.4.554

Mather, M., & Knight, M. R. (2006). Angry faces get noticed quickly: Threat detection is not impaired among older adults. *Journals of Gerontology, Series B: Psychological Sciences, 61B*, P54–P57.

Mogg, K., Bradley, B. P., de Bono, J., & Painter, M. (1997). Time course of attentional bias for threat information in non-clinical anxiety. *Behavioral Research Therapy, 35*, 297–303.

Nelson, H. E. (1976). A modified Wisconsin card sorting test sensitive to frontal lobe defects.

Cortex, *12*, 313–324.

Nummenmaa, L., Hyona, J., & Calvo, M. G. (2006). Eye movement assessment of selective

attentional capture by emotional pictures. *Emotion*, *6*, 257–268. doi: 10.1037/1528-

3542.6.2.257

Ohman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the

grass. *Journal of Experimental Psychology: General*, *130*, 466–478. doi:10.1037/0096-

3445.130.3.466

Ohman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: Toward an evolved module

of fear and fear learning. *Psychological Review*, *108*, 483–522. doi:10.1037/0033-

295X.108.3.483

Ohnishi, T., Matsuda, H., Tabira, T., Asada, T., & Uno, M. (2001). Changes in brain morphology

in Alzheimer's disease and exaggerated aging process? *American Journal of*

Neuroradiology, *22*, 1680–1685.

Petrides, M., & Milner, B. (1982). Deficits on subject-ordered tasks after frontal- and temporal-

lobe lesions in man. *Neuropsychologia*, *20*, 249–262. doi: 10.1016/0028-

3932%2882%2990100-2

Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative

social information. *Journal of Personality and Social Psychology*, *61*, 380–391. doi:

10.1037/0022-3514.61.3.380

Raz, N. (2000). Aging of the brain and its impact on cognitive performance: Integration of

structural and functional findings. In F. I. M. Craik & T. A. Salthouse (Eds.), *Handbook*

of aging and cognition (2nd ed., pp. 1–90). Mahwah, NJ: Erlbaum.

Reimann, B., & McNally, R. (1995). Cognitive processing of personally relevant information. *Cognition and Emotion, 9*, 324–340.

Rosler, A., Ulrich, C., Billino, J., Sterzer, P., Weidauer, S., Bernhardt, T., ... Kleinschmidt, A. (2005). Effects of arousing emotional scenes on the distribution of visuospatial attention: Changes with aging and early subcortical vascular dementia. *Journal of the Neurological Sciences, 229*, 109–116. doi:10.1016/j.jns.2004.11.007

Comment [a50]: Article with more than seven authors, 7.01, Example 2

Shipley, W. C. (1986). *Shipley Institute of Living Scale*. Los Angeles: Western Psychological Services.

Spielberger, C. D., Gorsuch, I., & Lushene, R. E. (1970). *Manual for the State-Trait Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Wechsler, D. (1987). *Wechsler Memory Scale—Revised*. San Antonio, TX: Psychological Corporation.

Wechsler, D. (1997). *Technical manual for the Wechsler Adult Intelligence and Memory Scale—III*. New York: The Psychological Corporation.

West, R. L. (1996). An application of prefrontal cortex function theory to cognitive aging. *Psychological Bulletin, 120*, 272–292. doi: 10.1037/0033-2909.120.2.272

Williams, J. M., Mathews, A., & MacLeod, C., (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin, 120*, 3–24. doi: 10.1037/0033-2909.120.1.3

Wilson, B. A., Alderman, N., Burgess, P. W., Emslie, H. C., & Evans, J. J. (1996). *The Behavioural Assessment of the Dysexecutive Syndrome*. Flempton, Bury St. Edmunds, England: Thames Valley Test Company.

Footnotes

Comment [e51]: Placement and format of footnotes, 2.12

¹ Analyses of covariance were conducted with these covariates, with no resulting influences of these variables on the pattern or magnitude of the results.

² These data were also analyzed with a 2×5 ANOVA to examine the effect of target category when presented only in arrays containing neutral images, with the results remaining qualitatively the same. More broadly, the effects of emotion on target detection were not qualitatively impacted by the distractor category.

Comment [e52]: Selecting effective presentation, 4.41; Logical and effective table layout, 5.08; Elements of table notes, 5.16

Table 1

Participant Characteristics

Measure	Young group		Older group		<i>F</i> (1, 46)	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Years of education	13.92	1.28	16.33	2.43	18.62	<.001
Beck Anxiety Inventory	9.39	5.34	6.25	6.06	3.54	.066
BADS–DEX	20.79	7.58	13.38	8.29	10.46	.002
STAI–State	45.79	4.44	47.08	3.48	1.07	.306
STAI–Trait	45.64	4.50	45.58	3.15	0.02	.963
Digit Symbol Substitution	49.62	7.18	31.58	6.56	77.52	<.001
Generative naming	46.95	9.70	47.17	12.98	.004	.951
Vocabulary	33.00	3.52	35.25	3.70	4.33	.043
Digit Span–Backward	8.81	2.09	8.25	2.15	0.78	.383
Arithmetic	16.14	2.75	14.96	3.11	1.84	.182
Mental Control	32.32	3.82	23.75	5.13	40.60	<.001
Self-Ordered Pointing	1.73	2.53	9.25	9.40	13.18	.001
WCST perseverative errors	0.36	0.66	1.83	3.23	4.39	.042

Note. The Beck Anxiety Inventory is from Beck et al. (1988); the Behavioral Assessment of the Dysexecutive Syndrome—Dysexecutive Questionnaire (BADS-DEX) questionnaire is from Wilson et al. (1996); the State–Trait Inventory (STAI) measures are from Spielberger et al. (1970); and the Digit Symbol Substitution, Digit Span Backward, and Arithmetic Wechsler Adult Intelligence and Memory Scale–III measures are from Wechsler (1997). Generative naming scores represent the total number of words produced in 60 s each for letter *F*, *A*, and *S*. the Vocabulary measure is from Shipley (1986); the Mental Control measure is from Wechsler (1987); the Self-Ordered Pointing measure was adapted from Petrides and Milner (1982); and the Wisconsin Card Sorting Task (WCST) measure is from Nelson (1976). All values represent raw, nonstandardized scores.

Table 2

Raw Response Time (RT) Scores for Young and Older Adults

Category	Young group	Older group
Positive high arousal	825	1,580
Positive low arousal	899	1,636
Neutral	912	1,797
Negative high arousal	885	1,578
Negative low arousal	896	1,625

Note. Values represent median response times, collapsing across array type and excluding arrays of the same category as targets (i.e., positive high arousal represents the median RT to respond to positive high arousal targets, collapsing across positive low arousal, neutral, negative high arousal, and negative low arousal array categories). The median response time values were recorded in milliseconds.

Figure 1. Mean difference values (ms) representing detection speed for each target category subtracted from the mean detection speed for neutral targets. No age differences were found in the arousal-mediated effects on detection speed. Standard errors are represented in the figure by the error bars attached to each column.

Comment [a53]: Elements of figure legends and captions, 5.23

Comment [a54]: Principles of figure use and construction, types of figures; standards, planning, and preparation of figures, 5.20–5.25

