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Aging and Visual Serial Search for Schematic Emotional Faces

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Abstract

The aim of the present study was to examine serial visual processing of facial emotion in a group of younger and older adults. Participants performed a visual serial search task in which they searched displays of schematic faces with positive, negative or neutral mouth expressions. Our findings show that older adults did particularly well when detecting positive target faces. Differently, their response times were slower on positive faces compared to negative and neutral faces. Explanations in terms of attentional disengagement mechanisms that may generate an age-related positivity effect are discussed.

Keywords

Aging, Emotion, Visual search

Introduction

Almost every description of cognitive deficit in aging underlines the importance and contribution of attentive impairments towards these deficits. Furthermore, an enormous amount of experimental literature reporting a wide variety of behavioral impairments (all thought to reflect deficits in attention), supports these findings. For example, deficits in detecting targets in series of visual stimuli in continuous performance tasks typically result from sustained attention failures [1], and failures to focus on relevant information are often discussed as representing difficulties in inhibition mechanisms [2]. Differently, selective attention deficits do not seem to be present with emotional stimuli. In fact, with both behavioral and neural measures, recent studies have shown how selective attention remains stable with age when emotional stimuli are involved [3] and, in particular, appears to play a crucial role in the generation of a positivity effect in aging as older adults show a preference in attention and memory towards positively valenced information.

In the present study, we aimed to isolate the contribution of attentional positive biases in aging by focusing on two specific components of attention, orientation towards emotional stimuli and disengagement [4]. Orienting processes determine what information is attended to and are responsible for directing attention towards relevant information. Disengagement, instead, refers to processes that operate once attention needs to be directed to another relevant object.

To do this, we created a serial visual search task with emotional stimuli. Visual serial search tasks have been extensively adopted to study various components of attention in the past 30 years [5-7]. In general, in this type of task participants search for a target object in an array containing many distractors and participant's reaction times (RTs) are registered as the main dependent variable. Although there are conflicting theories regarding visual search, there is broad agreement that the distinctiveness of the target relative to distractors is a major determinant of performance [8]. Visual search, therefore, may be very rapid and efficient when emotional stimuli are involved. Such highly efficient searches are sometimes called "pop-out" searches because the target appears to pop out from the distractors. Interestingly, a review by Frischen, Eastwood, & Smilek [9] about visual search for faces outlined how distinctiveness may not be the only crucial factor in visual searching as search processes seem to be differentially influenced by the emotional meaning of the facial expression and the emotional state of the observer. In all, the studies reported by Frischen et al. [10] seem to imply a more complex picture within the context of visual search for emotional stimuli. In this study, we chose to focus on a serial visual search task because when attention is shifted serially [11], visual search may better highilight the contribution of a) an orienting mechanism that directs attention towards relevant items and b) a disengagement mechanism that allows us to move attention from one object to another until the target is found.

Emotional Visual Search in Aging

Literature examining variants of visual search tasks with emotional stimuli in aging has yielded ambiguous results. For example, in a study [12], younger and older adults were asked to perform a visual search task for images that varied in terms of valence and arousal. Target and distractor images were simultaneously presented in a matrix and participants were instructed to respond as quickly as possible by pressing the key marked "yes" if the target was present or the key marked "no" if the target was not. Results showed faster reaction times for emotional stimuli compared to neutral stimuli across both groups. In addition, older adults did not show any advantage for positive information. According to these researchers, the absence of positivity effects depends on the fact that these effects may typically arise at later stages of processing (e.g. memory processes, emotion regulation) and therefore be absent in the earlier stages of processing required by a rapid visual search task. Differently, in another study [13] (experiment 2) using a visual search task, researchers found that older adults were more efficient at searching for angry distractors than happy or neutral distractors, indicating that older adults were better at disengaging from or inhibiting angry facial expressions. This result is consistent with the hypothesis that older adults are better at avoiding negative affect. Researchers [14] also measured attentional biases in aging using a dot-probe task and found a positivity effect. In their task, each trial presented a pair of faces on a computer screen for a brief interval. Subsequently, the faces disappeared and a dot appeared in one of the two positions previously occupied by the faces.

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Participants were instructed to indicate as quickly as possible which side of the monitor the dot appeared on. Older participants responded faster when the dot corresponded to the position of a positive face, while their responses were slower if the dot appeared where a negative face had appeared [15]. Although these studies differed in terms of methodology, it is important to note that all of them presented the emotional information simultaneously making it difficult to behaviorally disentangle the role of different attentional mechanisms such as disengagement (indispensable for moving attention from one type of target to another). For this reason, we chose to use a search task in which each matrix contained two possible targets (a valenced target and an "ad-hoc" distractor, which contains the same graphic elements but devoid of valence) and participants were required to search for both of them. In this manner, we were able to estimate how long participants attended to one target item before moving to the next one. In addition, when a search task requires a response indicating whether a target is present or absent, as done in the above-mentioned studies, participants may simply give up and press the 'no' button. This may be especially typical of older adults' performance under time constraints. To avoid this problem, participants were invited to scan each item by pressing the space bar in order to advance on each item and respond every time they encounter either the target or the ad-hoc distractor.

The Present Study

The aim of the present study was to investigate attention-related processes involved in visual search for emotional information in aging by assessing performance in an innovative serial search task for stimuli that varied in terms of emotional valence. The self-paced serial visual search task required participants to pay attention to an image when surrounded by a black frame. Participants were instructed to evaluate each image as quickly and accurately as possible. We carefully controlled the amount of feature overlap between targets and ad-hoc distractors keeping the demand for perceptual processing constant and invited participants to serially search for target and ad-hoc distractor information within the same display. The differences in RTs based on the valence of the target controlled for the RTs on ad-hoc distractor information were our primary interest. This index provided a measure of participants' ability to disengage from valenced target information while searching. First, we expected older adults to be slower in detecting and disengaging compared to younger adults independently of valence. Second, in line with existing literature [15,16] we expected older adults to be more sensitive than younger ones to positive information. In particular, if positivity effects occur because older adults spend more time on positive information and/or tend to disengage more slowly from positive information, we expect to register slower RTs on positive target trials in older adults compared to those of younger adults. Again, this finding would indicate a preference for positive information indexed through the increased time spent on positive faces or, to say it differently, to a "difficulty" in disengaging from positive facial expressions during visual search. Differently, if younger and older adults show comparable RTs on positive trials, this would indicate that disengagement is not a crucial attentional mechanism underlying the positivity effect and that, as shown in [12], other processes such as memory and emotion regulation strategies may be called on to explain this effect.

Table 1: Participant Characteristics.

	Younger	Older
Age	22.7 (2.1)	69.1 (5.6)*
Education (years)	16.8 (2.1)	10.7 (3.7)*
MMSE		28.9 (1.1)
Digit span (Forward)	7.6 (1.6)	5.4 (1.8)*
Digit span (Backward)	6.2 (2.1)	4.5 (6.2)*
Pattern Comparison		
RTs	63.1 (13.8)	154.1 (63.1)*
Accuracy	57.6 (2.7)	57.9 (2.7)
PANAS		
Positive	32.4 (8.3)	37.6 (7.6)
Negative	20.3 (6.5)	17.3 (5.8)

Note: Standard deviations are in parentheses; *$p < 0.05$

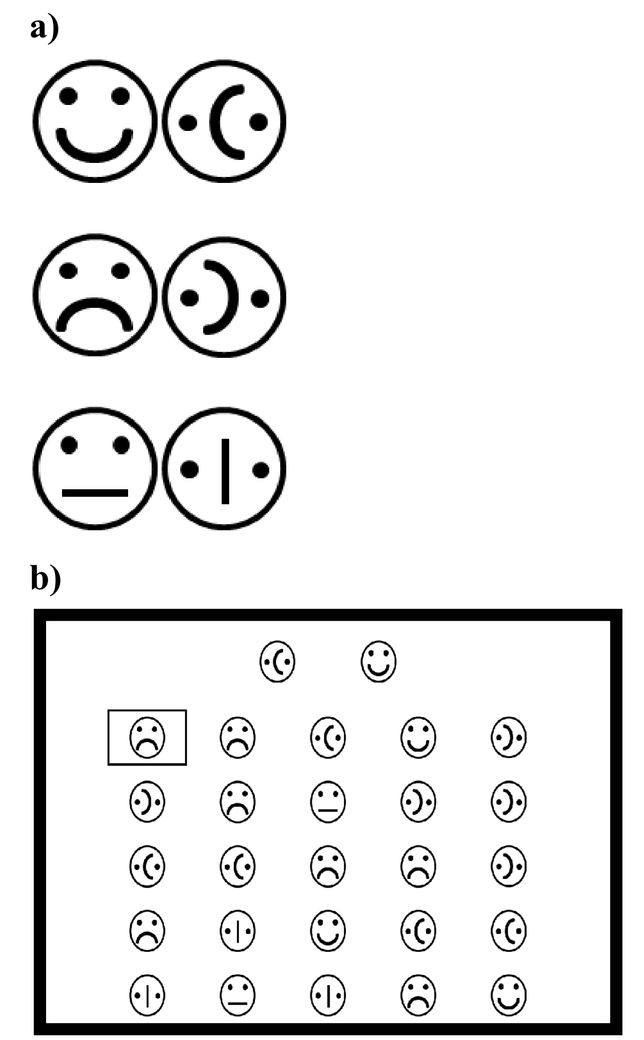

Figure 1: Materials and procedure of the experiment: (a) schematic depiction of valenced targets on the left and corresponding ad-hoc distractors on the right (b) visual array of stimuli: participants were instructed to serialy search for target information and ad-hoc distractor indicated at the top of the display.

Method

Participants

Thirty-one younger (12 males, M_{age} = 22.7, SD = 2.1) and 31 older adults (12 males, M_{age} = 69.1, SD = 5.6) participated in the experiment. Younger participants were recruited from psychology classes for class credit at the University of Chieti. Older participants were healthy home dwelling seniors recruited from local senior centers in Chieti. All participants reported having normal or corrected-to-normal vision and reported being able to see all of the stimuli. Older adults were also screened to ensure absence of primary degenerative brain disorders and other psychiatric conditions or medications that could affect cognitive performance.

Materials and procedure

Before starting the experimental session, each participant was administered the Digit Span Memory Test, which includes a forward and backward subtest [17] and the Positive and Negative Affect Scale (PANAS) [18]. The first task is based on memorization of short sequences of digits of increasing length, while the PANAS ask participants to indicate the frequency of positive and negative emotions on a 7-point scale during the last week (from 1 = not at all to 5 = absolutely). Older adults, in addition, completed the Mini-Mental State Examination (MMSE) [19] that was used as a screening tool for dementia. The mean values and t-test results for these tests are presented in table 1. One older participant gave up half way through the experimental task; therefore, we did not include his data in the analyses. The stimuli are shown in figure 1.

They were presented on a video monitor at a distance of approximately 70 cm. Each search array consisted of 25 schematic faces (diameter = 2.5 cm) drawn with black contours (5 × 3.4 cm) on a white background. There were six blocks of stimuli each containing six trials for a total of 36 arrays (12 positive, 12 negative and 12 neutral). Each block (containing six trials) was preceded by a blank screen. Participants decided when to start by pressing the spacebar. A one-second blank screen with a central fixation point preceded each trial within a block. In a typical search array, the to-be-searched target information was presented at the top of the screen, while 25 schematic faces occupied the remaining search region. These 25 items included randomly presented target information, ad-hoc distractors and other distractors (valenced target items and ad-hoc distractors from different blocks of trials). Each valenced target item was paired with an ad-hoc distractor created by scrambling the perceptual features of the valenced target information. Each search array could contain a different number of targets and the target and ad-hoc distractor's number and locations were balanced across each block of trials. Across the trials, there were a total of 150 positive, 150 negative and 150 neutral targets and a corresponding number of ad-hoc distractors. Participants were instructed to search as quickly and as accurately as possible for target information and ad-hoc distractors presented at the top of the display. To reduce the recruitment of memory processes, target information and the corresponding ad-hoc distractor remained on the screen during each trial. Participants were instructed to use the space bar to search each array. As participants moved through the arrays, items were serially highlighted by a black frame (from left to right and from the top row toward the bottom) in order to indicate advancement from one item to the next. Finally, participants were instructed to keep pressing the space bar until they encountered a target item. When participants encountered a target item they were instructed to press the enter key. The stimulus array remained on the screen until participants pressed the space bar on the last item. Prior to the experimental session, we provided instructions via a PowerPoint presentation, followed by one practice block. Short breaks were provided if participants manifested tiredness. Responses latencies and accuracy for each trial were recorded with E-Prime (Version 1.1.4.1) experimental software.

Results

Recognition accuracy

We conducted a first analysis on the difference between correctly identified target faces and errors. In general, all participants were highly accurate, with a mean of 80% correct or higher for each group, indicating that the RTs were not confounded by speed-accuracy trade-offs. A 2 (Group: younger vs.older adults) × 3 (Valence: positive, negative and neutral) mixed-model analysis of variance (ANOVA) did not revealed any significant effect, suggesting that both groups were good at identifing target faces during the serial visual search task. However, planned comparisons showed that older adults were particularly good at identifying positive target faces (87.6%) compared to the younger group (82.1%), $F(1,59) = 4.17$ $p < 0.05$ Mse = 0.04. No differences were detected across groups for negative (Young Adults = 82.9 %; Older Adults = 80.6%) and neutral target faces (Young Adults = 84.2%; Older Adults = 82.4%).

Reaction times

Rts for error trials were excluded (fewer than 9% of all responses) as were Rts that were +/- 2 *SD* from each participants' mean (approximately 3% of responses). Mean RTs were then calculated for each emotional valence category. The differential means of RTs for each group are presented in table 2.

Table 2: Mean Differential Response Time (RT) Scores in Milliseconds for Young and Older Adults. Standard Deviations are in parentheses.

Category	Young	Older
Positive	622.52 150.93)	1518.66 (554.67)
Negative	-69.35 (79.58)	-38.41 (163.50)
Neutral	-4.52 (42.70)	47.52 (137.20)

Note: Negative values indicate that participants were faster in detecting target information compared to the ad-hoc distractor.

Because our main interest was to investigate the effects of valence on participants' target detection times, we created scores for each emotional target category that controlled for the participant's RT to detect ad-hoc distractors (e.g. subtracting the RT to detect targets from the RT to detect ad-hoc distractors). This may be considered an index of each participant's ability to respond to and disengage from target information. These data were then analyzed using a 2 (Group: younger vs. older adults) × 3 (Valence: positive, negative and neutral) mixed-model analysis of variance (ANOVA). There was a significant effect of group, $F(1,59) = 62.74$ $p < 0.001$ Mse = 77655.48 as older adults' responses (509.26) were slower than those of younger adults (182.88). There was a significant effect of valence, $F(2,118) = 431.48$ $p < 0.001$ Mse = 55844.12. The mean differential RT score for positive information was 1063.24; it was -54.13 for negative information and 21.07 for neutral information. Planned comparisons showed that participants were slower on positive compared to negative, $F(1,60) = 207.96$ $p < 0.001$ Mse = 183110.79 and neutral information, $F(1,60) = 210.13$ $p < 0.001$ Mse = 157649.51. Participants' responses were faster on negative compared to neutral information, $F(1,60) = 17.84$ $p < 0.001$ Mse = 9668.85. Finally, the two-way interaction was significant, $F(2,118) = 66.50$ $p < 0.001$, (this interaction remained significant even after controlling for education, $p < 0.05$). In general, both groups were slower on positive information compared to negative and neutral information as shown in the main effect of valence. However, to verify whether older adults' RTs were especially slower than those of younger adults on positive information, we calculated a differential score between RTs for positive information and the mean RTs scores to negative and neutral information pooled together. This analysis revealed a tendency for older adults to hold on to positive information compared to other types of information (e.g., negative and neutral) with respect to younger adults, $F(1,59) = 72.84$ $p < 0.001$ Mse = 152869.58. The mean value was 1514.11 for older adults, while it was 659.45 for younger adults.

Discussion

In this study, we used a serial visual search task to isolate specific attentional mechanisms, such as disengagement, responsible for shifting the focus of processing from item to item while observers search for a target [11]. Researchers in previous studies with older adults have also examined visual search performance, but they generally found little or no preference for positive information at this early stage of processing [15]. The method used in the present study, however, was designed to be more sensitive than those used in previous studies [20], leading to two major findings. First, older adults displayed overall recognition accuracy for detecting positive information compared to other types of information, suggesting that positivity effects may arise at early stages of processing. Second, in line with this, we found some evidence for an age-related change in detection of emotional information, as older adults demonstrated remarkable slowing on positive information.This finding does not seem to reflect some sort of generalized slowing. If older adults produced a slowing of all processes involved in performing visual search, then the degree of slowing should have been proportional to each type of target, leading to the same percentage increase across conditions. The fact that the proportional difference between younger and older adults was almost than three times larger with positive targets than with negative or neutral targets provides strong evidence against an account based on generalized slowing. Our results argue instead, for a more specific bias in attentional mechanisms. In particular, there appears to be a bias in the processes that operate to identify a positive target together with a bias to hang on to it. In contrast with previous studies, our task emphasized the implementation of selection and disengagement of attention. The main determinants of visual searching are, in this case, the time required to determine whether a given item is a target and disengament from it. In this experiment, we predicted that differences in RT's of older adults would be largest in the positive trials compared with those of younger adults. The results are consistent with our predictions as older adults detected positive target information very rapidly, and under most conditions that involved one shift of attention, they tended to spend more time or hang on longer on positive compared with negative and neutral information. Although additional research is necessary to definitively distinguish between more controlled vs. automatic attention-shifting mechanisms that may generate positivity effects in the aging mind, our study seems to indicate a tendency for older adults to pay greater attention to positive information as a result of emotion regulation strategies. It has been shown, in fact, that although face expressions may preattentively affect visual processes, top-down modulations influence allocation of attention [21]. In recent years, cognitive and emotion research [22] has repeatedly shown an age-related enhancement effect in cognitive tasks when emotional stimuli are involved. Laura Carstensen and colleagues [23] explained this emotional advantage in terms of an age-related selectivity towards emotional goals. According to their theory, emotional processing becomes the priority as older adults approach the end of their life span and perceive a corresponding change in time perspective. These researchers, in fact, emphasize how the proximity of the end of an individuals' life span may generate a cognitive shift towards emotion processing, boosting emotion information processing in general and positive emotion processing in particular. What is clear, from this study at this point is that top-down strategies (e.g. emotion regulation, well-being) in aging guided search efficiency for different target expressions at the first analysis of stimulus processing. Given that we tried to reduce the intervention of memory processes by maintaining target and ad-hoc distractor information on screen, the recruitment of more bottom-up processes coupled with the emotional state of participants (as shown by the PANAS scores) may explain our results. In sum, visual search performance may vary widely depending on perceptual and strategic factors associated with target information and this may hold particularly true for older adults. Future behavioural and neuroimaging studies together with complex emotion-cognition interaction models may help us to better understand the role of different attentional mechanisms in the generation of positivity effects in the aging mind: a tendency to disengage more slowly from positive information may be one of them.

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