Automatic and controlled attentional orienting in the elderly: A dual-process view of the positivity effect

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Abstract

The positivity effect in the elderly consists of an attentional preference for positive information as well as avoidance of negative information. Extant theories predict either that the positivity effect depends on controlled attentional processes (socio-emotional selectivity theory), or on an automatic gating selection mechanism (dynamic integration theory). This study examined the role of automatic and controlled attention in the positivity effect. Two dot-probe tasks (with the duration of the stimuli lasting 100 ms and 500 ms, respectively) were employed to compare the attentional bias of 35 elderly people to that of 35 young adults. The stimuli used were expressive faces displaying neutral, disgusted, fearful, and happy expressions. In comparison to young people, the elderly allocated more attention to happy faces at 100 ms and they tended to avoid fearful faces at 500 ms. The findings are not predicted by either theory taken alone, but support the hypothesis that the positivity effect in the elderly is driven by two different processes: an automatic attention bias toward positive stimuli, and a controlled mechanism that diverts attention away from negative stimuli.

Keywords	positivity effect; controlled attentional processes; automatic attentional processes; dot-probe task

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June, 15, 2017

Dear Editor,

Please find enclosed the manuscript titled "Automatic and controlled attentional orienting in the elderly: A dual-process view of the positivity effect" by Righi, S., Gronchi, G., Pierguidi, L., Giovannelli, F., Murasecco, I., and Viggiano, M.P. for consideration in *Acta Psychologica*.

The present work aims at casting light on the attentional mechanisms underlying the positivity effect. The positivity effect is an age-related trend that favors positive over negative stimuli in cognitive processing. Two theories predict either that the positivity effect relies on controlled attentional processes (socio-emotional selectivity theory), or on an automatic gating selection mechanism (dynamic integration theory). To our knowledge this is the first study that systematically investigates the role of automatic and controlled attention on the positivity effect. To explore this issue, we compared young and elderly subjects by employing two dot-probe tasks which differ for the duration of the stimuli (100 ms and 500 ms, respectively). The stimuli used were expressive faces displaying neutral, disgusted, fearful, and happy expressions. Our results showed that elderly (in comparison to young people) allocated more attention to happy faces at 100 ms and they tended to avoid fearful faces at 500 ms. These results are not predicted by either theory taken alone, but support the idea that the positivity effect in the elderly is driven by two different processes: an automatic attention bias toward positive stimuli, and a controlled mechanism that diverts attention away from negative stimuli.

The present manuscript is original, not previously published, and not under concurrent consideration elsewhere. The participants were treated in accordance with the ethical guidelines of the University of Florence and informed consent was obtained from all the subjects. All authors have agreed to submit the present version of the manuscript.

I look forward to hearing about your editorial decision.

Sincerely,

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Abstract

The positivity effect in the elderly consists of an attentional preference for positive information as well as avoidance of negative information. Extant theories predict either that the positivity effect depends on controlled attentional processes (socio-emotional selectivity theory), or on an automatic gating selection mechanism (dynamic integration theory). This study examined the role of automatic and controlled attention in the positivity effect. Two dot-probe tasks (with the duration of the stimuli lasting 100 ms and 500 ms, respectively) were employed to compare the attentional bias of 35 elderly people to that of 35 young adults. The stimuli used were expressive faces displaying neutral, disgusted, fearful, and happy expressions. In comparison to young people, the elderly allocated more attention to happy faces at 100 ms and they tended to avoid fearful faces at 500 ms. The findings are not predicted by either theory taken alone, but support the hypothesis that the positivity effect in the elderly is driven by two different processes: an automatic attention bias toward positive stimuli, and a controlled mechanism that diverts attention away from negative stimuli.

Automatic and controlled attentional orienting in the elderly:

A dual-process view of the positivity effect

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Abstract

The positivity effect in the elderly consists of an attentional preference for positive information as well as avoidance of negative information. Extant theories predict either that the positivity effect depends on controlled attentional processes (socio-emotional selectivity theory), or on an automatic gating selection mechanism (dynamic integration theory). This study examined the role of automatic and controlled attention in the positivity effect. Two dot-probe tasks (with the duration of the stimuli lasting 100 ms and 500 ms, respectively) were employed to compare the attentional bias of 35 elderly people to that of 35 young adults. The stimuli used were expressive faces displaying neutral, disgusted, fearful, and happy expressions. In comparison to young people, the elderly allocated more attention to happy faces at 100 ms and they tended to avoid fearful faces at 500 ms. The findings are not predicted by either theory taken alone, but support the hypothesis that the positivity effect in the elderly is driven by two different processes: an automatic attention bias toward positive stimuli, and a controlled mechanism that diverts attention away from negative stimuli.

Keywords :

positivity effect, controlled attentional processes, automatic attentional processes, dot-probe task

Introduction

Adaptive and flexible behavior depending on context is a hallmark of human adult cognition (Kumano, Suda & Uka, 2016; Gronchi & Strambini, 2016; Gronchi & Provenzi, 2017; Pierguidi et al., 2016; Righi, Gronchi, Marzi, Rebai, & Viggiano, 2015; Van den Stock, Righart, & De Gelder, 2007). Conversely, cognitive aging has been conceived as characterized by an intractable and rigid decline of performance (Hedden & Gabrieli, 2004; Harada, Love, & Triebel, 2013). However, recent research has emphasized both the flexibility of cognitive processes and the enhancement of abilities related to emotion-cognition interaction in older adults (Charles & Carstensen, 2013), as demonstrated by the positivity effect. The positivity effect is an age-related trend that favors positive over negative stimuli in cognitive processing (Carstensen & Mikels, 2005; Reed & Carstensen, 2012). This effect is revealed in a variety of memory domains (Mather & Carstensen, 2003; Comblain, D'Argembeau, & Van der Linden, 2005; Spaniol, Voss, & Grady, 2008; Scheibe & Carstensen, 2010), including working memory (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005), short-term memory (Charles, Mather, & Carstensen, 2003), autobiographical memory (Kennedy, Mather, & Carstensen, 2004); Schlagman, Schulz, & Kvavilashvili, 2006), and false memories (Fernandes, Ross, Wiegand, & Schryer, 2008).

There are two models of cognitive-affective aging that may explain the positivity effect: the socio-emotional selectivity theory (SST; e.g., Carstensen, Isaacowitz, & Charles, 1999; Carstensen & Mikels, 2005; Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005) and the dynamic integration theory (DIT; Labouvie-Vief, 2003, 2005, 2009; Labouvie-Vief, Grühn, & Mouras, 2009). The SST (Mather & Carstensen, 2003) is a lifespan theory of motivation which assumes that the core constellation of goals changes throughout adulthood as a function of future time horizons. Since older adults have a decreased future time perspective, they consciously emphasize goals of well-being and emotional stability (Carstersen, Mikels, & Mather, 2006). According to the idea that the positivity effect involves deliberate cognitive strategies, the more recent extension of SST (although not central to the original model) is that positivity effects are the result of controlled attentional processes (Reed & Carstensen 2012).

Alternatively, the DIT (Labouvie-Vief, 2003) is an integrative model of emotional development aimed at explaining the pattern of both gains and losses in cognitive affective functioning across the lifespan.

According to DIT, the positivity effect is related to affect optimization*,* which is an automatic process associated with declining cognitive resources in aging (e.g., Labouvie-Vief, 2003). The DIT states that due to their age-related limitation in cognitive resources, older adults have difficulties in managing the cognitive-affective complexity. Hence, an adaptive attentional mechanism would automatically preserve cognitive processing by gating out emotional stimuli, especially when distress and threat-related.

In both theories, attentional mechanisms have been invoked as the main causes of the positivity effect. Both SST and DIT predict age-related differences in the processing of emotional material whereby the processing of negative information declines, whereas that of positive information is stable or improves with age (Carstensen, Isaacowitz, & Charles, 1999; Labouvie-Vief, 2003). However, different predictions may be derived from the role that attention plays in each theory. SST assumes that the positivity effect depends on late (controlled) attentional processes, whereas according to DIT, such an effect involves early (automatic) attentional processes. Much effort has been devoted to investigating attentional orienting in late adulthood; this has generally produced mixed results and focused mainly on late (controlled) attentional processes. According to some authors (Charles, Mather, & Carstensen, 2003; Ready, Weinberger, & Jones, 2007; Shamaskin, Mikels, & Reed, 2010), age-related differences in attentional orienting are driven by the greater attention paid by younger people to negative material. Also, older adults showed an attentional facilitation for positive (vs. negative) material (Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Mather, & Knight, 2005). There is also evidence that older participants divert attention away from negatively valenced materials (Mather & Carstensen, 2003; Mather & Knight, 2006; Orgeta, 2011). However, in many cases, a difference in emotional attention between younger and older adults was not observed (Hahn, Carlson, Singer, & Gronlund, 2006; Leclerc & Kensinger, 2008; Mather & Knight, 2006; Demeyer & De Raedt, 2013; Murphy & Isaacowitz, 2008). Generally, the majority of this research has been aimed at confirming the SST predictions of a conscious and voluntary attentional shift toward positive, and/or away from negative, material. Since the focus was on controlled (overt) top-down processes (which require conscious attention), attentional orienting has been mainly investigated through dot-probe tasks with long (from 500 ms) duration of stimuli (Isaacowitz, Allard, Murphy, & Schlangel, 2009).

The few works that have explored more automatic attentional mechanisms have employed eye tracking procedures and dot-probe tasks with long stimuli presentations (2000 ms) (Isaacowitz, Wadlinger, Goren, & Wilson, 2006a, 2006b; Allard & Isaacowitz, 2008). Older adults directed their gaze toward happy and away from angry or sad faces, but relatively late after stimulus presentation (from 500 ms) (Isaacowitz, Wadlinger, Goren & Wilson, 2006a, 2006b). Hence, it has been concluded that positivity bias requires an overt controlled (top-down) attentional orienting (Isaacowitz, Wadlinger, Goren & Wilson, 2006a, 2006b; Reed & Carstensen, 2012).

Crucially, such previous studies investigated the timeline of overt gaze patterns, but did not directly explore automatic (bottom-up) stimulus-driven attentional orienting, which is only evident with stimuli presentation at around 100 ms (Koster, Verschuere, Crombez, & Van Damme, 2005; Cooper & Langton, 2006). So, the critical issue of determining at what stage of attentional processing the positivity bias has an impact has yet to be explored.

Here, we aim to investigate the key role of automatic and controlled attentional mechanisms in the positivity effect. The primary concern is to establish which model of cognitive-affective aging—SST or DIT—better predicts the observed positivity bias in older adults. To explore this issue, we used two dot-probe procedures that varied for the duration of the stimuli (100 ms and 500 ms durations) (Cooper & Langton, 2006). The dot-probe has been employed in previous research on attentional bias in the elderly by using only long stimuli durations (1000 ms) (Mather & Carstensen, 2003). The dot-probe task involves the presentation of a pair of stimuli for a fixed time period, followed by the appearance of a visual probe in one of the two stimulus locations. Our stimuli were faces with neutral, positive (happy), negative (disgusted), and negative threat-related (fearful) expressions. Participants are required to localize the probe. By varying the time between the onset of the stimuli and the appearance of the probe, one can assess both the automatic covert attention and the controlled overt attention (Cooper & Langton, 2006).

Considering the main models of cognitive-affective aging, different predictions can be made: (i) according to the SST (Baltes & Carstensen, 2003; Isaacowitz, Allard, Murphy, & Schlangel, 2009; Reed & Carstensen 2012), the positivity effect should be elicited by controlled (overt) top-down processes that require conscious attention and should only be observed with long stimuli presentations (at 500 ms); (ii) following the DIT (Carstensen, Isaacowitz, & Charles, 1999; Labouvie-Vief, 2003), which implies that an automatic affect optimization has been finalized to preserve the cognitive processing, we can suppose an early avoidance of negative stimuli, especially when threat related. Hence, older adults should divert their attention away from fearful expressions from as early as 100 ms.

Method

Participants

Thirty-five young (17 male), and 35 elderly (18 male) healthy adults participated in the experiment. All participants had normal or corrected-to-normal vision and had not suffered from any neurological diseases. The groups were comparable for anxiety (State-Trait Anxiety Inventory – STAI) and depression (Beck Depression Inventory – BDI) (Table 1). Demographic and test data are reported in Table 1. Ethical approval was obtained.

====================== *please insert Table 1 about here* ====================

Materials

Sixteen face identities (8 female) were taken from the Karolinska Directed Emotional Faces (KDEF) database (Lundqvist, Flykt, & Öhman, 1998). For each identity, the photographs (totaling 64 faces) comprised neutral, disgusted, fearful, and happy expressions. Faces were presented in a grey rectangular frame that measured 8.5 cm by 5.5 cm on the screen. A neutral face was paired with the same identity displaying one of four emotional expressions: angry, fearful, happy, or neutral. The face-pairs were presented on a black background, with one face on the left and the other face on the right, separated by 6 cm.

Procedure

Two dot-probe tasks with different stimuli durations (SOA) of 100 ms (short duration) and 500 ms (long duration) were run under E-Prime in counterbalanced order across participants.

Each dot-probe task consisted of one block of practice stimuli (3 neutral-neutral picture pairs) followed by 8 randomized experimental blocks, each containing 28 face-pairs: 24 emotional-neutral face-pairs (8 disgusted-neutral, 8 fearful-neutral, and 8 happy-neutral, of which 12 were congruent and 12 were incongruent[1]), and 4 neutral-neutral face pairs for a total of 224 face-pair presentations. Each emotional-neutral face-pair was randomly presented 4 times with an equal number of both congruent and incongruent probe presentations and left vs. right locations. The other 32 neutral-neutral pairs of faces of the same identity were included to act as a baseline in order to control for which mechanisms (i.e., facilitation or inhibition) might be responsible for any observed attentional biases (Koster, Crombez, Verschuere, & De Houwer, 2004).

Each dot-probe task was composed of 32 trials that consisted of three sequential components: (i) a central white fixation cross (500 ms); (ii) a 100 or 500 ms simultaneous presentation of two faces (face-pairs) located immediately to the left and to the right of the fixation cross; and (iii) a white asterisk (i.e., dot-probe) appearing in either the left or right location immediately after the offset of the faces. Subjects had to press two buttons to indicate the position of the dots (see Figure 1).

====================== *please insert Figure 1 about here* ====================

Results

The data analysis for the dot-probe tasks was based on reaction times (RTs) for correct responses (between 99.1 and 97% for young and elderly participants in each of the dot-probe tasks). RTs shorter than 200 ms or longer than 2000 ms were removed from the data (Koster et al., 2004). Furthermore, individual outliers (defined as RTs that deviated more than three SDs from the individual mean latency time) were also discarded. Since a preliminary analysis (ANOVA) revealed no main effect or interaction of picture position (left vs. right), (all $p_s > 0.05$) RTs were collapsed across the factor picture position. Following previous research (Koster, Crombez, Verschuere, & De Houwer, 2004; Koster, Verschuere, Crombez, & Van Damme, 2005; Cooper & Langton, 2006), we conducted three different repeated measure ANOVAs on the data, and post-hoc comparisons used the Bonferroni correction.

In order to evidence absolute differences between the groups, we compared the mean RTs for conditions (Table 2). To simplify the two-, three-, and four-way significant interactions that emerged from

[1] Congruent and incongruent mean that the emotional face and the dot appear in the same or in the opposite location, respectively.

this ANOVA on mean RTs (Table 2), individual attentional bias indexes (ABIs) were calculated by subtracting mean RTs on congruent trials from mean RTs on incongruent trials for each type of emotional face-pair (Koster, Verschuere, Crombez, & Van Damme, 2005).

====================== *please insert Table 2 about here* =====================

Positive ABI values reflect attention toward the emotional face (vigilance), and negative values reflect attention away from the emotional face (avoidance). ANOVA results for the ABIs are displayed in Table 3a and in Figure 2. These results revealed that at a duration of 100 ms, the elderly allocated more attention to the happy faces than the younger subjects ($p < 0.001$), and at a duration of 500 ms, the elderly avoided the fearful faces ($p < 0.001$). This finding indicated the direction of the attentional biases, but it is unclear whether the bias toward the happy face at 100 ms, for example, was a result of the facilitation of attention to its location, or an avoidance of its incongruent location.

To disentangle this point (Koster, Verschuere, Crombez, & Van Damme, 2005; Cooper & Langton, 2006), we compared the congruent emotional conditions with the neutral baseline by computing the Attentional Facilitation Index (AFI) (Koster, Verschuere, Crombez, & Van Damme, 2005; Cooper & Langton, 2006). The AFI was computed by subtracting from the baseline RTs of the trials of neutral-neutral face-pairs the mean of each of the three congruent emotional-neutral conditions. Positive AFI values indicate that facilitation (attentional capture) was due to the congruent emotional location, whereas negative AFI values would suggest inhibition (avoidance) of congruent emotional locations compared to neutral baseline responses (Koster, Crombez, Verschuere, & De Houwer, 2004). The AFI results (Table 3b and c, and Figure 2) showed that in the 100 ms condition, the elderly were facilitated in their processing of happy faces in comparison to the young subjects. Automatic attention of the young is captured by negative threat (fearful) and non-threat-related (disgusted) expressions, whereas the elderly pay preferential attention to happy faces.

====================== *please insert Table 3 about here* =====================

====================== *please insert Figure 2 about here* =====================

The elderly were not impaired at 100 ms in their processing of fearful or disgusted faces; however, this pattern changed at 500 ms when the elderly diverted their attention away from fearful (vs. both disgusted and happy) and disgusted (vs. happy) expressions. Nevertheless, at 500 ms, the elderly differed from the young only in their tendency to avoid (inhibition) the fearful expressions.

Discussion and Conclusion

The present study aimed at exploring the role of automatic and controlled attentional mechanisms in the age-related positivity effect. By using the dot-probe task with short duration, we were able to investigate automatic orienting. When compared to the young subjects, the elderly were facilitated in their processing of happy faces, but they were not impaired in their automatic attention toward fearful faces. This cannot be attributed to different levels of affective dysfunction, since the two groups did not differ with regard to anxiety or depression. Rather, the differences could be associated with age-related changes in the medial prefrontal cortex (Gunning-Dixon et al., 2003; Williams, et al., 2006). This neural structure is less activated in elderly people, thereby allowing positive responses to proceed without restraint during early perceptual appraisal (Williams et al., 2006).

With regard to the long duration, the results are in line with previous evidence (Mather & Carstensen, 2003), as the elderly participants tended to avoid fearful and disgusted faces when compared to neutral faces. This may reflect a top-down controlled mechanism that voluntarily diverts attentional orienting from negative stimuli.

Overall, the results cannot be explained by either SST or DIT alone, but both theories suggest that there are two different mechanisms that may play a role in the positivity effect. Attentional processing of emotional stimuli in the elderly could be determined by an automatic attention bias toward positive stimuli, mediated by the gating out process for emotional stimuli assumed by the DIT (Allard & Isaacowitz, 2008; Samanez-Larkin & Carstensen, 2011; Thomas & Hasher, 2006), and a controlled mechanism based on the SST (Samanez-Larkin & Carstensen, 2011) that deliberately diverts attention away from negative stimuli. Therefore, our findings support a dual-process account of the age-related positivity effect. According to this hypothesis, aging may produce adaptive changes not only in the voluntary components of attention (Isaacowitz, Allard, Murphy, & Schlangel, 2009), but also in the automatic mechanism. This dual-process perspective of the positivity effect strengthens the view regarding human aging as a flexible and complex phenomenon that differentially affects automatic and controlled processes.

References

Allard, E. S., & Isaacowitz, D. M. (2008). Are preferences in emotional processing affected by distraction? Examining the age-related positivity effect in visual fixation within a dual-task paradigm. *Aging, Neuropsychology, and Cognition, 15*(6), 725-743.

Baltes, M. M., & Carstensen, L. L. (2003). The process of successful aging: Selection, optimization, and compensation. In U. M. Staudinger & U. Lindenberger (Eds.), *Understanding human development: Dialogues with lifespan psychology* (pp. 81-104). NY: Springer.

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*(3), 117-121.

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist, 54*(3), 165-181.

Carstensen, L. L., Mikels, J. A., & Mather, M. (2006). Aging and the intersection of cognition, motivation and emotion. In J. E. Birren, K. W. Schaie, R. P. Abeles, M. Gatz & T. A. Salthouse (Eds.) *Handbook of the Psychology of Aging* (pp. 343-362). Amsterdam: Elsevier.

Charles, S. T., & Carstensen, L. L. (2013). Emotion regulation and aging. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (pp. 203–218). New York: Guilford.

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*(2), 310.

Comblain, C., D'Argembeau, A., & Van der Linden, M. (2005). Phenomenal characteristics of autobiographical memories for emotional and neutral events in older and younger adults. *Experimental Aging Research, 31*(2), 173-189.

Cooper, R. M., & Langton, S. R. (2006). Attentional bias to angry faces using the dot-probe task? It depends when you look for it. *Behaviour Research and Therapy, 44*(9), 1321-1329.

Demeyer, I., & De Raedt, R. (2013). Attentional bias for emotional information in older adults: The role of emotion and future time perspective. *PloS One, 8*(6), e65429.

Fernandes, M., Ross, M., Wiegand, M., & Schryer, E. (2008). Are the memories of older adults positively biased? *Psychology and Aging, 23*(2), 297-306.

Gronchi, G., & Provenzi, E. (2017). A variational model for context-driven effects in perception and cognition. *Journal of Mathematical Psychology, 77*, 124-141.

Gronchi, G., & Strambini, E. (2016) Quantum cognition and bells inequality, a model for probabilistic judgment bias. *Journal of Mathematical Psychology*.

Gunning-Dixon, F. M., Gur, R. C., Perkins, A. C., Schroeder, L., Turner, T., Turetsky, B. I., Robin, M. C., Loughead, J. W. Alsop, D. C., Maldjian, J., & Gur, R. E. (2003). Age-related differences in brain activation during emotional face processing. *Neurobiology of Aging, 24*(2), 285-295.

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*(3), 312-336.

Harada, C. N., Love, M. C. N., & Triebel, K. L. (2013). Normal cognitive aging. *Clinics in Geriatric Medicine, 29*(4), 737-752.

Hedden, T., & Gabrieli, J. D. (2004). Insights into the ageing mind: a view from cognitive neuroscience. *Nature Reviews Neuroscience, 5*(2), 87-96.

Isaacowitz, D. M., Allard, E. S., Murphy, N. A., & Schlangel, M. (2009). The time course of age-related preferences toward positive and negative stimuli. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, gbn036.

Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006a). Is there an age-related positivity effect in visual attention? A comparison of two methodologies. *Emotion, 6*(3), 511-516.

Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006b). Selective preference in visual fixation away from negative images in old age? An eye-tracking study. *Psychology and Aging, 21*(1), 40-48.

Kennedy, Q., Mather, M., & Carstensen, L. L. (2004). The role of motivation in the age-related positivity effect in autobiographical memory. *Psychological Science, 15*(3), 208-214.

Knight, M., Seymour, T. L., Gaunt, J. T., Baker, C., Nesmith, K., & Mather, M. (2007). Aging and goal-directed emotional attention: distraction reverses emotional biases. *Emotion, 7*(4), 705-714.

Koster, E. H., Crombez, G., Verschuere, B., & De Houwer, J. (2004). Selective attention to threat in the dot probe paradigm: Differentiating vigilance and difficulty to disengage. *Behaviour Research and Therapy, 42*(10), 1183-1192.

Koster, E. H., Verschuere, B., Crombez, G., & Van Damme, S. (2005). Time-course of attention for threatening pictures in high and low trait anxiety. *Behaviour Research and Therapy, 43*(8), 1087-1098.

Kumano, H., Suda, Y., & Uka, T. (2016). Context-dependent accumulation of sensory evidence in the parietal cortex underlies flexible task switching. *Journal of Neuroscience, 36*(48), 12192-12202.

Labouvie-Vief, G. (2003). Dynamic integration affect, cognition, and the self in adulthood. *Current Directions in Psychological Science, 12*(6), 201-206.

Labouvie-Vief, G. (2009). Cognition and equilibrium regulation in development and aging. *Restorative Neurology and Neuroscience, 27*(5), 551-565.

Labouvie-Vief, G., Grühn, D., & Mouras, H. (2009). Dynamic emotion-cognition interactions in adult development: Arousal, stress, and the processing of affect. In Bosworth, H. B., & Hertzog, C. (Eds) *Aging and cognition: Research methodologies and empirical advances*, (pp. 181-196). Washington, DC, US: American Psychological Association.

Labouvie-Vief, G. (2005). Self-with-other representations and the organization of the self. *Journal of Research in Personality 39*(1), 185-205.

Leclerc, C. M., & Kensinger, E. A. (2008). Effects of age on detection of emotional information. *Psychology and Aging, 23*(1), 209.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). The Karolinska directed emotional faces (KDEF). CD ROM from *Department of Clinical Neuroscience, Psychology section, Karolinska Institutet*, 91-630.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*(1), 15.

Mather, M., & Knight, M. R. (2006). Angry faces get noticed quickly: Threat detection is not impaired among older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 61*(1), 54-57.

Mather, M., & Carstensen, L. L. (2003). Aging and attentional biases for emotional faces. *Psychological Science, 14*(5), 409-415.

Mikels, J. A., Larkin, G. R., Reuter-Lorenz, P. A., & Carstensen, L. L. (2005). Divergent trajectories in the aging mind: changes in working memory for affective versus visual information with age. *Psychology and Aging, 20*(4), 542.

Murphy, N. A., & Isaacowitz, D. M. (2008). Preferences for emotional information in older and younger adults: a meta-analysis of memory and attention tasks. *Psychology and Aging, 23*(2), 263.

Orgeta, V. (2011). Avoiding threat in late adulthood: testing two life span theories of emotion. *Experimental Aging Research, 37*(4), 449-472.

Pierguidi, L., Righi, S., Gronchi, G., Marzi, T., Caharel, S., Giovannelli, F., & Viggiano, M. P. (2016). Emotional contexts modulate intentional memory suppression of neutral faces: Insights from ERPs. *International Journal of Psychophysiology, 106*, 1–13.

Ready, R. E., Weinberger, M. I., & Jones, K. M. (2007). How happy have you felt lately? Two diary studies of emotion recall in older and younger adults. *Cognition and Emotion, 21*(4), 728-757.

Reed, A. E., & Carstensen, L. L. (2012). The theory behind the age-related positivity effect. *Frontiers in Psychology, 3*.

Righi, S., Gronchi, G., Marzi, T., Rebai, M., & Viggiano, M. P. (2015). You are that smiling guy I met at the party! Socially positive signals foster memory for identities and contexts. *Acta Psychologica, 159*, 1–7.

Ruffman, T., Henry, J. D., Livingstone, V., & Phillips, L. H. (2008). A meta-analytic review of emotion recognition and aging: Implications for neuropsychological models of aging. *Neuroscience & Biobehavioral Reviews, 32*(4), 863-881.

Samanez-Larkin, G. R., & Carstensen, L. L. (2011). Socioemotional functioning and the aging brain. In J. Decety & J.T. Cacioppo (Eds.) *The Handbook of Social Neuroscience* (pp. 507-521). New York: Oxford University Press.

Scheibe, S., & Carstensen, L. L. (2010). Emotional aging: Recent findings and future trends. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, gbp132.

Schlagman, S., Schulz, J., & Kvavilashvili, L. (2006). A content analysis of involuntary autobiographical memories: Examining the positivity effect in old age. *Memory, 14*(2), 161-175.

Shamaskin, A. M., Mikels, J. A., & Reed, A. E. (2010). Getting the message across: age differences in the positive and negative framing of health care messages. *Psychology and Aging, 25*(3), 746.

Spaniol, J., Voss, A., & Grady, C.L (2008). Aging and emotional memory: cognitive mechanisms underlying the positivity effect. *Psychology and Aging, 23*(4), 859-872.

Thomas, R. C., & Hasher, L. (2006). The influence of emotional valence on age differences in early processing and memory. *Psychology and Aging, 21*(4), 821-825.

Van den Stock, J., Righart, R., & De Gelder, B. (2007). Body expressions influence recognition of emotions in the face and voice. *Emotion, 7*(3), 487–494.

Williams, L. M., Brown, K. J., Palmer, D., Liddell, B. J., Kemp, A. H., Olivieri, G., Peduto, A., & Gordon, E. (2006). The mellow years? Neural basis of improving emotional stability over age. *The Journal of Neuroscience, 26*(24), 6422-6430.

Figure captions:

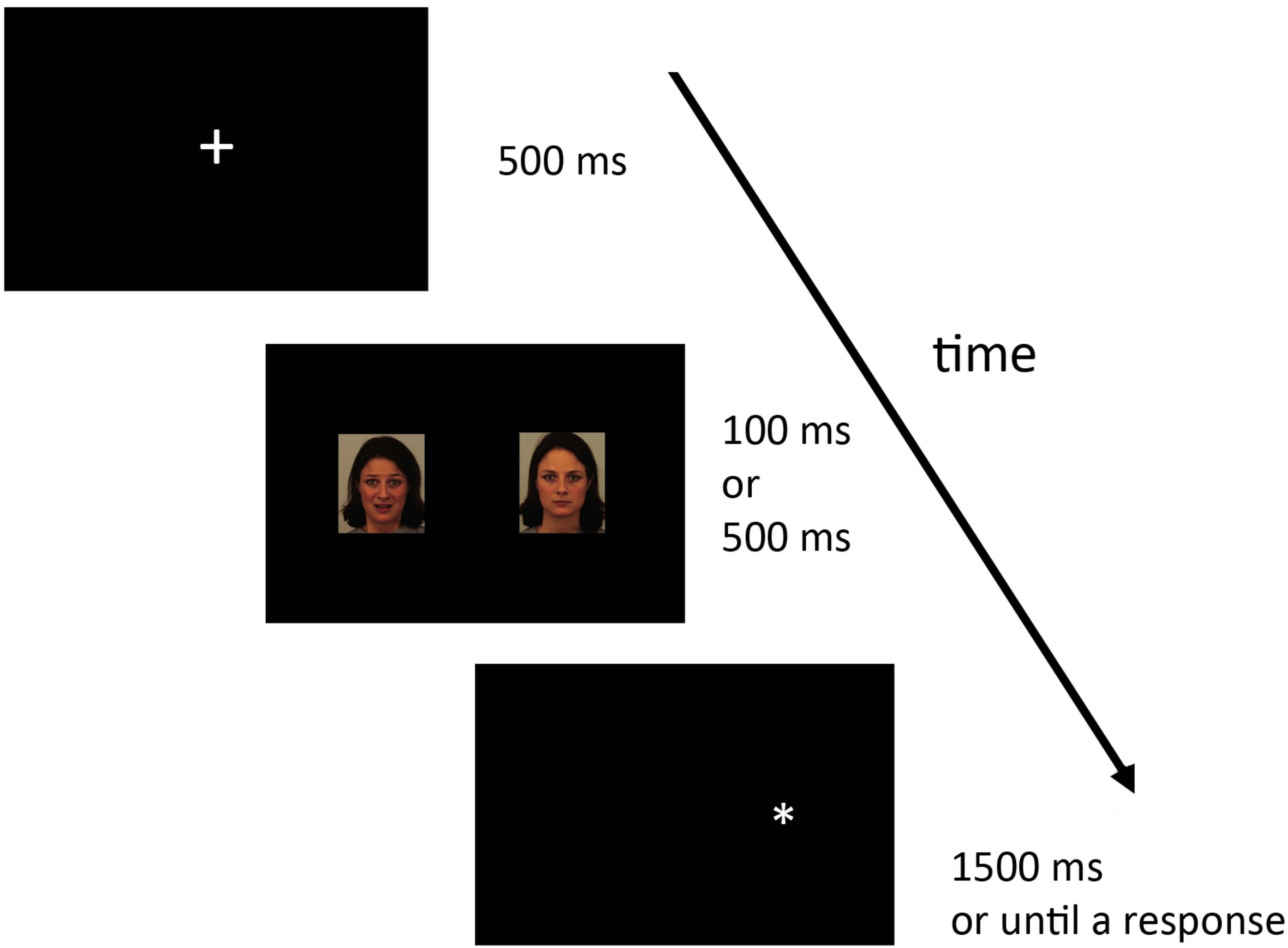
Figure 1 – Dot probe task: experimental procedure

Figure 2 – Attentional Bias Indexes (ABIs) and Attentional Facilitation Indexes (AFIs) for both durations (100 ms and 500 ms) in young and elderly subjects as a function of the emotional expressions. Error bars represent 1 SEM. *$p < 0.05$, **$p < 0.01$.

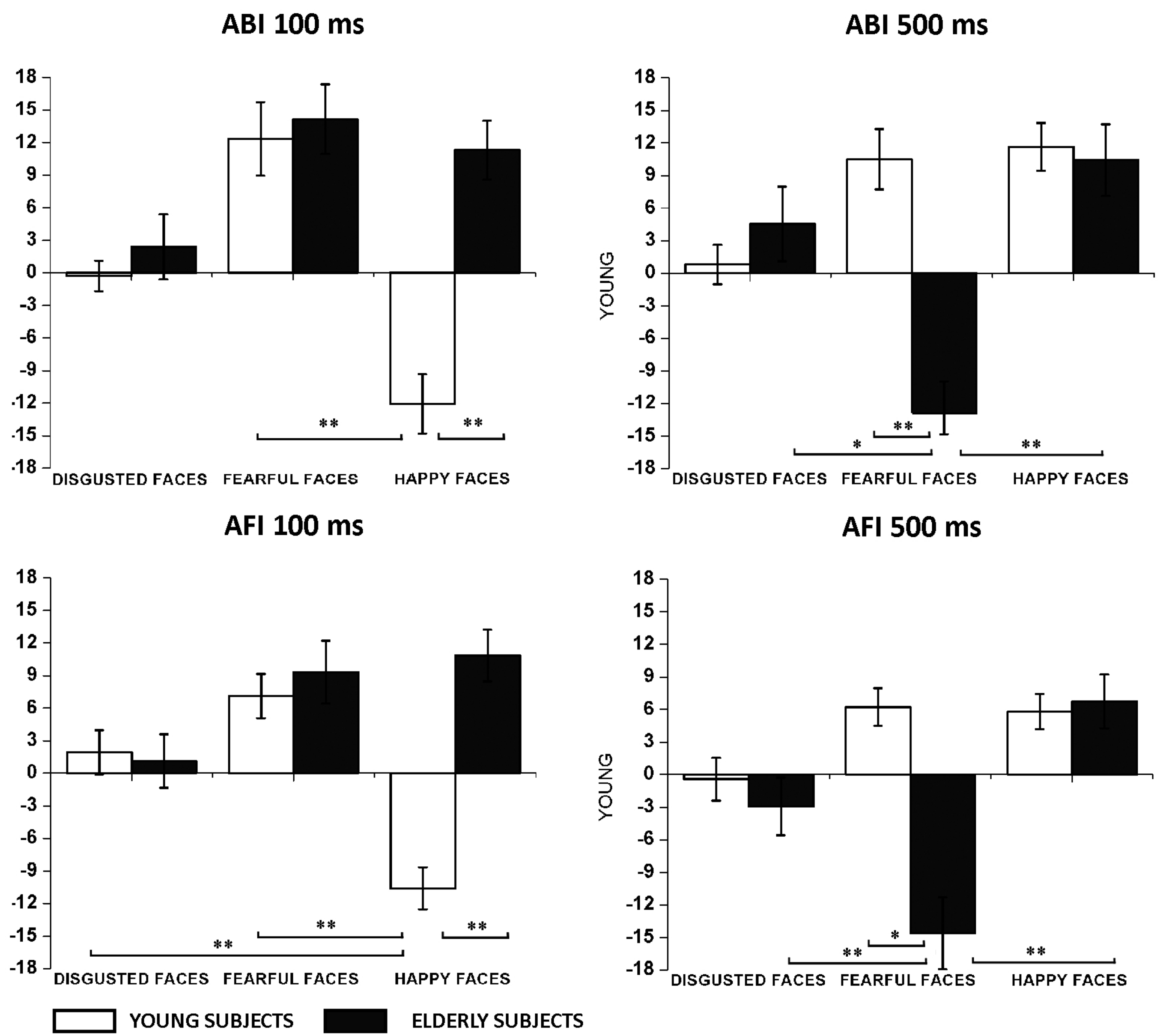
Table 1 – Demographic and test data for young and elderly subjects.

Table 2 – Results from the ANOVA on the Reaction Times (RTs) and post-hoc comparison for main effects.

Table 3 – Results from the ANOVA on the: **a)** Attentional Bias Index (ABI) **b)** Attentional Facilitation Index (AFI) and post-hoc comparison.



500 ms
time
100 ms
or
500 ms
*
1500 ms
or until a response


ABI 100 ms
ABI 500 ms
AFI 100 ms
AFI 500 ms
18
15
12
9
6
3
0
-3
-6
-9
-12
-15
-18
YOUNG
**
*
DISGUSTED FACES
FEARFUL FACES
HAPPY FACES
YOUNG SUBJECTS
ELDERLY SUBJECTS

	Age-range (years)	Mean age (SD)	STAI-trait	STAI-state	BDI
Young	20-30	27.26 (3.28)	36.66 (5.97)	33.54 (7.35)	6.61 (3.44)
Elderly	70-89	77.11 (6.84)	36.12 (7.63)	34.66 (7.70)	7.06 (4.45)
t-student (p value)		-38.40 (0.001**)	0.33 (0.74)	-0.62 (0.54)	-0.48 (0.63)

Table 1

ANOVA on the RTs : Duration (100 ms. Vs 500 ms) x Emotional face (Disgusted, fearful, happy) x Congruency (Congruent vs. incongruent) x Group (Young vs. elderly)	
Statistics	**Post-hoc comparisons**
Congruency , F (1,68) = 14.11, p < 0.001, η_p^2= 0.18	Incongruent > congruent (means = 525.39 and 521.13, respectively)
Group, F (1,68) = 124.73, p < 0.001, η_p^2= 0.65	Elderly > Young (means = 653.98 and 392.53, respectively)
Emotional face x Group, F (2,135) = 7.38, p < 0.001; η_p^2= 0.10	Post-hoc were conducted by computing Attentional Bias Index (ABI)
Duration x Congruency x Group, F (1,68) = 11.74, p < 0.001, η_p^2= 0.15	
Emotional face x Congruency x Group, F (2,122) = 7.24, p < 0.002, η_p^2= 0.11	
Duration x Emotional face x Congruency, F (2,136) = 10.80, p < 0.001, η_p^2= 0.14	
Duration x Emotional face x Congruency x Group, F (2,136) = 3.11, p < 0.05, η_p^2= 0.05	

Table 2

ANOVA on the ABI: Duration (100 ms vs. 500 ms) x Emotional face (Disgusted, fearful, happy) x Group (Young vs. elderly)	
Statistics	**Post-hoc comparisons**
Duration x Group, $F (1,68) = 11.58$, $p < 0.001$, $\eta_p^2 = 0.15$	At 100 ms: ABI of young < elderly (p=0.005); at 500 ms: ABI of young > elderly (p=0.042); In young ABI of 100 ms < ABI of 500 ms (p=0.026), in elderly: ABI of 100 ms > ABI of 500 ms (p=0.13)
Emotional face x Group, $F (2,120) = 7.38$, $p < 0.002$, $\eta_p^2 = 0.10$	Fearful faces: ABI of young > ABI of elderly (p=0.028); Happy faces: ABI of Elderly > ABI of young (p=0.003); In young ABI of fearful > ABI of happy (p=0.022), in elderly: ABI
Duration x Emotional face, $F (2,136) = 10.70$, $p < 0.001$, $\eta_p^2 = 0.14$	At 100 ms: ABI of fearful > ABI of disgusted (p=0.009); ABI of fearful > ABI of happy (p=0.001); At 500 ms: ABI of happy > ABI of fearful (p=0.001); In fearful faces: ABI of 100 ms > ABI of 500 ms (p=0.001); in happy faces: ABI of 100 ms < ABI of 500 ms (p=0.010);
Duration x Emotional face x Group, $F (2,136) = 3.52$, $p < 0.032$, $\eta_p^2 = 0.05$	At 100 ms : in young ABI of fearful > happy (p=0.001); in elderly n.s.; At 500 ms: in young n.s.; in elderly ABI of fearful < disgusted (p=0.021); ABI of fearful < happy (p=0.001); In fearful faces ABI of young n.s, ABI of elderly: 100 ms > 500 ms (p=0.001); In happy faces ABI of young 100 ms < 500 ms (p=0.001), ABI of elderly n.s; At 100 ms in ABI of happy: elderly > young (p=0.001); at 500 ms in ABI of fearful: elderly > young (p=0.001)

Table 3a

ANOVA on the AFI : Duration (100 ms vs. 500 ms) x Emotional face (Disgusted, fearful, happy) x Group (Young vs. elderly)	
Duration x Group, $F (1,68) = 10.40$, $p < 0.002$, $\eta_p^2 = 0.14$	At 100 ms: AFI of young < elderly (p=0.005); at 500 ms: AFI of young > elderly (p=0.042); In elderly: AFI of 100 ms > AFI of 500 ms (p=0.002);
Emotional face x Group, $F (2,123) = 12.31$, $p < 0.001$, $\eta_p^2 = 0.15$	In fearful faces: AFI of young > AFI of elderly (p=0.023); in happy faces: AFI of elderly > ABI of Young (p=0.001); In young: AFI of fearful > AFI of happy (p=0.022), in elderly: AFI of happy > AFI of disgusted (p=0.001), AFI of happy > AFI of fearful (p=0.003);
Duration x Emotional face, $F (2,135) =10.52$, $p < 0.001$, $\eta_p^2 = 0.13$	At 100 ms: AFI of fearful > AFI of disgusted (p=0.043); AFI of fearful > AFI of happy (p=0.034); At 500 ms: AFI of happy > AFI of disgusted (p=0.04); : AFI of happy > AFI of fearful (p=0.003); In fearful faces: AFI of 100 ms > AFI of 500 ms (p=0.001); in happy faces: AFI of 100 ms < AFI of 500 ms (p=0.050);
Duration x Emotional face x Group, $F (2,135) = 4.15$, $p < 0.02$, $\eta_p^2 = 0.06$	At 100 ms: in young AFI of disgusted > happy (p=0.005), AFI of fearful > happy (p=0.001); in elderly AFI of disgusted < happy (p=0.041); At 500 ms: in young n.s.; in elderly AFI of fearful < disgusted (p=0.042); AFI of fearful < happy (p=0.001); AFI of disgusted < happy (p=0.022); In fearful faces: AFI of young: n.s, AFI of elderly: 100 ms > 500 ms (p=0.001); In happy faces: AFI of young: 100 ms < 500 ms (p=0.001), AFI of Elderly n.s; At 100 ms in AFI of happy: elderly > young (p=0.001), at 500 ms in AFI of fearful: elderly > young (p=0.001)

Table 3b

Table 3