It Is Not Always Positive: Emotional Bias in Young and Older Adults

Giada Viviani[1], Francesca De Luca[1], Gabriella Antonucci, Alla Yankouskaya[2] & Anna Pecchinenda[1]

Affiliation 1; Department of Psychology, Sapienza University of Rome, Italy

Affiliation 2, Department of Psychology, Bournemouth University, U.K.

Corresponding Author:

Anna Pecchinenda

Email: anna.pecchinenda@uniroma1.it

Telephone:+39 6 4991 7530

Fax: +39 6 4991 7711

Keywords: emotional conflict, interference, ageing, emotional bias

Draft, please do not quote

Abstract

Healthy ageing has been associated to a bias toward positive information and greater psychological well-being. However, to what extent this positivity bias also applies to prioritizing positive information under emotional competition is unclear. Old and young adults performed a word-face interference task, in which they responded to the valence of positive and negative target-words while ignoring happy or angry distractor-faces that could be affectively congruent or incongruent. A control condition with scrambled neutral distractor-faces was also used. Findings showed small facilitation effects with faster responses when targets and distractors were affectively congruent and large interference effects with slower responses when targets and distractors were affectively incongruent compared to the control condition. Importantly, whereas for younger adults there was a similar pattern of interference from happy and angry distractor-faces, for older adults there was greater interference from angry distractor-faces. The present findings are discussed in the context of emotional bias literature.

Word-count: 150

Introduction

Attending to some information while ignoring other relies on an interplay of goal-driven and stimulus-driven mechanisms. Goal-driven, selective attention requires cognitive control, which allows active maintenance of processing priorities in working memory and provides biasing signals in favour of goal-relevant stimuli (e.g., Corbetta & Shulman, 2002; Desimone & Duncan, 1995). Stimulus-driven selective attention can be allocated more automatically, that is based on the perceptual salience of stimuli (Corbetta, Patel, & Shulman, 2008; Theeuwes, 1994). In addition to goal-driven and stimulus-drive attention, selection mechanisms also prioritize information with emotional and motivational significance (i.e., motivated or emotional attention, Lang & Bradley, 2010; Pourtois, Schettino, & Vuilleumier, 2013; Vuilleumier, 2005). The mechanisms underlying motivated or emotional attention are supported by neural circuitry centred on the amygdala, which via feedback to sensory processing areas, biases the neural representation of emotional stimuli over competing neutral ones (i.e., Pessoa, 2009; Pourtois et al., 2013). When emotional stimuli are competing for selective attention, the focus is on the factors affecting what is prioritized (i.e., which emotional category or valence) and whether processing priorities might differently affect the resolution of conflict for negative and positive stimuli. In fact, it has been argued that negative information, and particularly threat-related one, is prioritized over other information due to the adaptive value of detecting potential harm (Öhman & Mineka, 2001). On the other hand, what is prioritized for attention may depend on personal goals and concerns of the individual with threat-related information being prioritized by anxious individuals (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007) and positive information being prioritized by old individuals (e.g., Mather & Carstensen, 2003, Isaacowitz, Wadlinger, Goren, & Wilson, 2006).

Traditionally, the bias toward positive information– referred to as positivity effect – has been linked to the well-being of older adults (Kunzmann et al., 2014). Among developmental theories of ageing, the Socio-emotional Selectivity Theory (SST) attributes the positive bias to a motivated shift toward positive information: older adults would use their cognitive resources to direct their attention to positive information with the aim of enhancing their emotional well-being (for reviews, see Carstensen et al., 1999; Scheibe & Carstensen, 2010; Reed & Carstensen, 2012). That is, the positivity effect is attributed to a frontal over-recruitment with a reduction in amygdala activation for negative stimuli due to increased frontal activity for emotional stimuli (e.g., St. Jacques, Bessette-Symons, & Cabeza, 2009). However, this frontal over-recruitment may reflect greater involvement of control processes to down-regulate negative stimuli but also a posterior-anterior shift (Davis, Dennis, Daselaar, Fleck, & Cabeza, 2008) with greater difficulty perceiving negative stimuli and spared perception of positive stimuli. For example, Ruffman, Henry, Livingston, and Phillips (2008) found that older adults show impaired recognition of angry and sad faces but are less impaired with happy faces. Therefore, the positivity effect represents a marker of well-being and healthy ageing if it results from over-recruitment of control mechanisms to down regulate affect. In contrast, it represents cognitive decline if it results from an impairment in processing negative stimuli. In both cases, which emotional information is prioritized under emotional conflict may differ between younger and older individuals.

Studies using a variety of experimental paradigms and stimuli have provided evidence that older adults show an attentional preference toward positive stimuli (e.g., Isaacowitz, et al., 2006; Sasse, Gamer, Buchel, & Brassen, 2014). In contrast, evidence from the emotional Stroop task (Stroop, 1935) shows similar interference from emotional stimuli for older and younger adults (e.g., Ashley & Swick, 2009). Indeed, in a recent review of the literature, Kauschke, Bahn, Vesker, and Schwarzer (2019) conclude that whether there is a valence-specific preference with one valence being prioritized over the other and whether this prioritization changes with age is still unclear. In addition to the classical Stroop task, research has also used other variants of the task entailing the simultaneous presentation of faces and words because there is a high degree of ecological co-occurrence between these two sources of information. In one variant – the flanker task (Eriksen &

Eriksen, 1974), target-words and distractor-faces are simultaneously presented at different spatial locations (e.g., Petrucci & Pecchinenda, 2017) and in another variant more similar to the Stroop task, emotional words are superimposed onto emotional distractor-faces (e.g., Stenberg, Viking, & Dahl, 1998; Pecchinenda & Heil, 2007; Pecchinenda, Ferlazzo, Lavidor, 2015). In all cases, targets and distractors can be either affectively congruent or incongruent. When participants respond to targets while ignoring distractors, emotional conflict is high if target and distractor are affectively incongruent. Therefore, varying the affective congruence between target and distractor allows to assess which specific emotion or valence prioritizes attention under conflict. Although the task can require responding to words and ignoring faces or vice versa, interference effects are larger when participants respond to emotional words, which has been interpreted as due to faces being processed more automatically than words (e.g., Beall & Herbert, 2008). In fact, ERPs studies show that emotional faces modulate early ERPs (i.e.,100 ms post-stimulus) in addition to the mid- and late-latency components (e.g., N170; EPN around 200-350 ms; LPP from 400 ms post-stimulus). In contrast, emotional words modulate a negative ERP component at a similar latency as the face-sensitive N170, (e.g., Frühholz, Jellinghaus, & Herrmann, 2011).

Evidence from the word-face interference task with emotional stimuli concerning which emotional valence is prioritized is mixed. When unequal proportion of congruent and incongruent trials has been used, which affects conflict and modulates the magnitude of the interference effects (e.g., Krug & Carter, 2012), there is reduced interference from frequent incongruent distractors, and this effect is independent of distractors' emotion (e.g., Preston & Stanfield, 2008; Baggott, Palermo, & Fox, 2011). In contrast, when equal proportion of congruent and incongruent trials has been used, it is difficult to draw clear conclusions on which valence is prioritized as studies vary on important methodological aspects. Namely, although in all studies participants respond based on the emotion of the target-word (Stenberg et al., 1998; Haas, Omura, Constable & Canli, 2006**;** Zhu, Zhang, Wu, Luo, & Luo, 2010; Strand, Oram, & Hammar, 2013), sometimes the evaluation entails an identity match between the emotion of the target and that of the distractor such as when the label "happy" or labels related to happiness (i.e., joyful) are presented on a happy distractor-face (e.g., Ektin, Egner, Peraza, Kandel, & Hirsch, 2006; Egner, Ektin, Gale, & Hirsch, 2008; Zhu et al., 2010; Strand et al., 2013; Chechko, Augustin, Zvyagintsev, Schneider, Habel, & Kellermann, 2013; Yang, Wang, Yin, Zhao, Tan, & Chen, 2016; Kohn, Hermans & Fernández, 2017; Fernandes, Garcia-Marques, Prada & Martins, 2019). Other times, positive or negative target-words are presented with positive (happy) or negative faces (sad, afraid or angry) and participants assess whether the target-word denotes something good/positive or bad/negative (e.g., Stenberg et al., 1998; Haas et al., 2006; Beall & Herbert, 2008; Hu, Liu, Weng, & Northoff, 2012; Strand et al., 2013). More specifically, Beall and Herbert, (2008) presented happy and sad (angry in exp. 2) distractor-faces and a control condition with blurred distractor-faces. Target-words were prototypical adjectives of the emotional category of the distractor-face (i.e., happy-face, joyful, etc.) and participants responded to targets based on valence (i.e., positive/negative). Findings showed greater interference from happy than sad faces (exp. 1) but similar interference effects from happy and angry distractor-faces (exp. 2). Yang et al., (2016) presented the words "happy" and "fear" superimposed onto happy and fearful distractor-faces and participants responded to target-words based on valence (i.e., positive/negative) while instructed to ignore the faces. Findings showed interference from happy but not from fearful distractor-faces. Similarly, Kohn et al., (2017) presented the words "happy" and "fear" onto happy and fearful distractor-faces and participants responded based on whether words were related to happiness or fear while performing the task under control or stress conditions. Findings showed larger interference effects from fearful distractor-faces in both conditions. Finally, Fernandes et al., (2019) presented words that were prototypical adjectives of happiness and anger onto happy and angry distractor-faces and participants responded based on whether target-words were related to happiness or anger. Findings (for the alone condition) showed that the interference from angry distractor-faces tended to be greater than from happy distractor-faces.

In summary, when young adults perform the word-face interference task emotional distractor-faces engender conflict and yield interference when they are affectively incongruent with target-words. However, which valence engenders greater interference is controversial. That fearful distractor-faces sometimes elicit less interference than happy distractor-faces has been attributed to threat-related distractors being processed faster and, under certain conditions, facilitating emotional conflict resolution (Kanske & Kotz, 2010). That is, threat-related stimuli (fearful but also angry faces) may engender facilitation effects when target and distractors are affectively congruent and less interference when they are affectively incongruent, allowing an individual to respond promptly to potentially threatening situations (Pessoa, 2009). The only way to assess whether this is the case entails using a control condition with neutral distractors, in addition to positive and negative distractors. However, with the exception of Beall and Herbert (2008) who reported similar interference effects from angry and happy distractor-faces, a control condition has not always been used in the word-face interference task.

Concerning using the word-face interference task with healthy old adults, it is surprising that there is only a handful of studies. Nevertheless, some of the evidence hints at old and young adults showing similar interference from positive and negative distractors. Specifically, Monti, Weintraub, and Egner, (2010) presented happy and fearful target-faces with the words happy and fear as a distractor superimposed onto the face. In the emotion task, participants categorized faces as happy or fearful (emotion-identity match) and ignored the words, in the gender task participants categorized faces as male or female (i.e., this was the control condition for the emotion task) and ignored the words. Interference was greater in the emotion task and it was similar for older and younger adults regardless of the type of emotion. Augustí, Satorres, Pitarque, and Meléndez (2017) presented happy and sad faces with superimposed the labels of the emotional category (i.e., happy or sad). In one block, participants responded to the word (emotion-identity match) and ignored the face, whereas in the other block they responded to the face (emotion-identity match) and ignored the word. There was no control condition. Findings showed greater interference from sad distractor-faces than from happy distractor-faces and the interference from emotional distractor-faces was similar for young and old adults. Finally, Meléndez, Satorres, and Oliva (2020) used a task similar to the one just described and compared performance of healthy old adults with that of old adults with Alzheimer Disease (AD). The authors presented happy and sad faces with superimposed the labels of the emotional category (i.e., happy, fear and sad). Again, there was no control condition. Participants responded by indicating the emotion of the word or the emotion of the face (emotion-identity match). Findings for the block in which healthy old adults responded to words and ignored faces, showed greater interference from sad distractor-faces. Surprisingly, healthy old adults also showed interference (i.e., longer RTs) from sad distractor-faces when presented with congruent target-words.

In summary, the available evidence from the word-face interference task suggests that interference is greater from negative faces (in both studies, sad distractor-faces) and that old and young adults show similar interference. However, this evidence has two critical limitations: Firstly, it is limited to tasks based on emotion-identity matching (i.e., happy-word with happy-face) between targets and distractors, which may call upon different strategies as it involve using a small set of target-words and many repetitions. Secondly and most importantly, no control condition was used to disentangle facilitation effects by affectively congruent distractor-faces from interference effects from incongruent distractor-faces. When comparing congruent and incongruent conditions any difference could be due to facilitation, interference, or both. ~~Therefore, to what extent~~ However, if older adults prioritize positive information over negative one then facilitation effects should be greater for positive than for negative affectively congruent word-face pairs and interference effects should be greater from affectively incongruent, positive distractor-faces.

In the present study, healthy old and young individuals completed a word-face interference task in which emotional words were presented superimposed onto happy, angry, or neutral scrambled faces (i.e., the control condition). Participants were instructed to respond to the words, by assessing whether they denoted something good or bad, while ignoring the faces. We used angry and happy faces as negative, threat-related and positive, reward-related expressions associated with approach motivation (Carver & Harmon-Jones, 2009; Wilkowski & Meier, 2010) to rule out potential motivational effects on response latency.

Method

Participants

Thirty-four university students (11 males and 23 females, age *M*= 23.65; *SE* = .695) and 34 older adults (16 males and 18 females, age *M* = 74.85; SE= .581) took part in the study. The sample size was a priori calculated using More Power software (Campbell & Thompson, 2012) based on the effect size reported by Augustì et al., (2017) for the word-task condition (η_p^2 = 0.129; α = .05; β – 1 = .95). This established that with a η_p^2= 0.129, α = 0.05, power = 0.98, 34 participants are necessary to detect a moderate-large effect. We used the effect size from Augustí et al. (2017) to estimate our sample size because in their study, participants responded to words while ignoring faces, and because young and healthy older adults completed the task. We did not use Melèndez et al (2017) because their findings hint to the possible contribution of participants' response strategies.

Older adults were recruited from senior centers and were screened using the Italian version of the Montreal Cognitive Assessment (MoCA, Nasreddine, Phillips, Bédirian, Charbonneau, Whitehead, Collin, Cummings, Chertkow, 2005) validated by Santangelo, Siciliano, Pedone, Vitale, Falco, Bisogno, Siano, Barone, Grossi, Santangelo and Trojano (2015) to exclude individuals with pathological cognitive decline (cut-off 15.5; for the recruited sample: MoCA M= 24.72 *SE* = .514). The Italian version of the Penn State Worry Questionnaire (PSWQ) validated by Morani, Pricci and Sanavio (1999) was used to exclude older adults with high levels of habitual worry (cut-off 2 SD; for the recruited sample: PSWQ *M* = .65 SE= .159) as it is a central feature of generalized anxiety disorders (e.g., Roemer, Molina, & Borkovec, 1997) and it is also associated to other emotional disorders such as obsessive compulsive disorders and depression (e.g., Molina, Borkovec, Peasley, & Person, 1998).

All participants had normal or corrected to normal vision and were naïve to the experimental hypotheses. Participants gave their written informed consent, which was obtained according to the Declaration of Helsinki (1991). The experiment was in compliance with institutional guidelines and had received approval by the Department of Psychology Ethics Committee, at Sapienza University.

Stimuli

Target-Words: Sixty words (30 positive and 30 negative nouns) were selected from the Italian validation (Montefinese, Ambrosini, Fairfield, & Mammarella, 2014) of the Affective Norms for English Words (Bradley & Lang, 1999), which has been shown to be reliable across different ages (Fairfield, Ambrosini, Mammarella & Montefinese, 2017). Twelve words (6 positives, 6 negative) were used as targets in the practice session, and other 48 words (24 positives, 24 negative) were used as targets in the experimental session.

For the experimental set, positive and negative words differed on valence (positive: M = 7.53; SE =.12; negative: M = 2.78; SE = .15, t (46) = 24.80, p < .001), but were balanced on arousal (positive: M = 5.44; SE = .16; negative: M = 5.60; SE = .21, t (46)= .6, p = .55), and word length (positive: M = 7.08; SE = .22; negative: M = 7.00; SE =.18, t (46)= -.3 p = .77). The selected words were also controlled for semantic associations using the Italian association norms (Peressotti, Pesciarelli, & Job, 2002). When a word was missing from the Italian association norms, the English translation was used and associations were controlled through the University of South Florida Free Association Norms (Nelson, McEvoy, & Schreiber, 2004).Words denoting the prototypical emotion-category and derivates of the emotion shown by the distractor-faces were not included (e.g., happiness, joyful, happy, joy, smile, etc.).

Distractor-Faces: Full colour photographs (13.23 x 16.53 cm) of 48 middle-age faces (24 males and 24 females), were selected from the FACES database based on available ratings for old and young participants (Ebner, Riediger & Lindenberger, 2010). Of these, 16 were angry faces (8 males, 8 females), 16 were happy faces (8 males, 8 females) and 16 were neutral faces (8 males, 8 females). Neutral faces, edited in scrambled images of 50 pixels using Matlab, were used as controls. Twelve additional faces were selected for the practice trials (See Appendix A for the complete list of stimuli).

All pictures were edited, adjusted to the centre and balanced for brightness using Adobe Photoshop 6.0 with an average brightness value of 106.5 cd/m^2. When presented on screen, faces measured 14.8 x 12.4 cm. Words were presented in uppercase, lime green**,** bold, 45-point Arial font (Baggott et al., 2011) pre-tested for readability. The font is larger than the minimum size (19 pixels or 14 points size) required for older adults (Redish, 2012). Each of the 48 words was presented superimposed onto each type of distractor-face (happy, angry, scrambled) at the height of the nose. Stimuli were presented on a 19-inch LCD monitor (resolution 1920 × 1080, refresh rate 60 Hz), subtending 13° of visual angle when presented at 60 cm of distance. Stimulus presentation and data collection were controlled using E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA, 2012) for Windows 7, which also records participants' responses. Responses were entered using a standard USB-keyboard with timing error less than 1 ms.

Procedure

After obtaining informed written consent, older individuals were administered the MoCA and completed the PSWQ. Selected participants were invited to come to the laboratory on a different day to take part in the experiment. Participants sat in front of a computer in a dimly lit room. Task instructions were presented on screen and after 12 practice trial, participants completed 6 blocks of 48 trials each for a total of 288 trials, resulting from the factorial combination of distractor type ad target-word. Therefore, each block consisted of equally probable factorial combination of Target-Word Valence (positive, negative) and Condition (congruent, incongruent, control) so that target and distractor could be congruent (i.e., positive target-word/happy distractor-face or negative target-word/angry distractor-face), incongruent (i.e., positive target-word/angry distractor-face or negative target-word/happy distractor-face) or control (i.e., positive or negative target-words/scrambled distractor-face). In each block, targets and distractors were presented only once, and the distractor-faces were always of different identities.

Each trial started with a centrally presented fixation cross (250 ms), followed by the word-face pair, which remained on screen until response. A response feedback (“Correct”, “Wrong” or “No response”) followed for 500 ms. The inter-trial interval varied randomly between 500 ms and 1500 ms (see Figure 1).

Insert Figure 1 about here

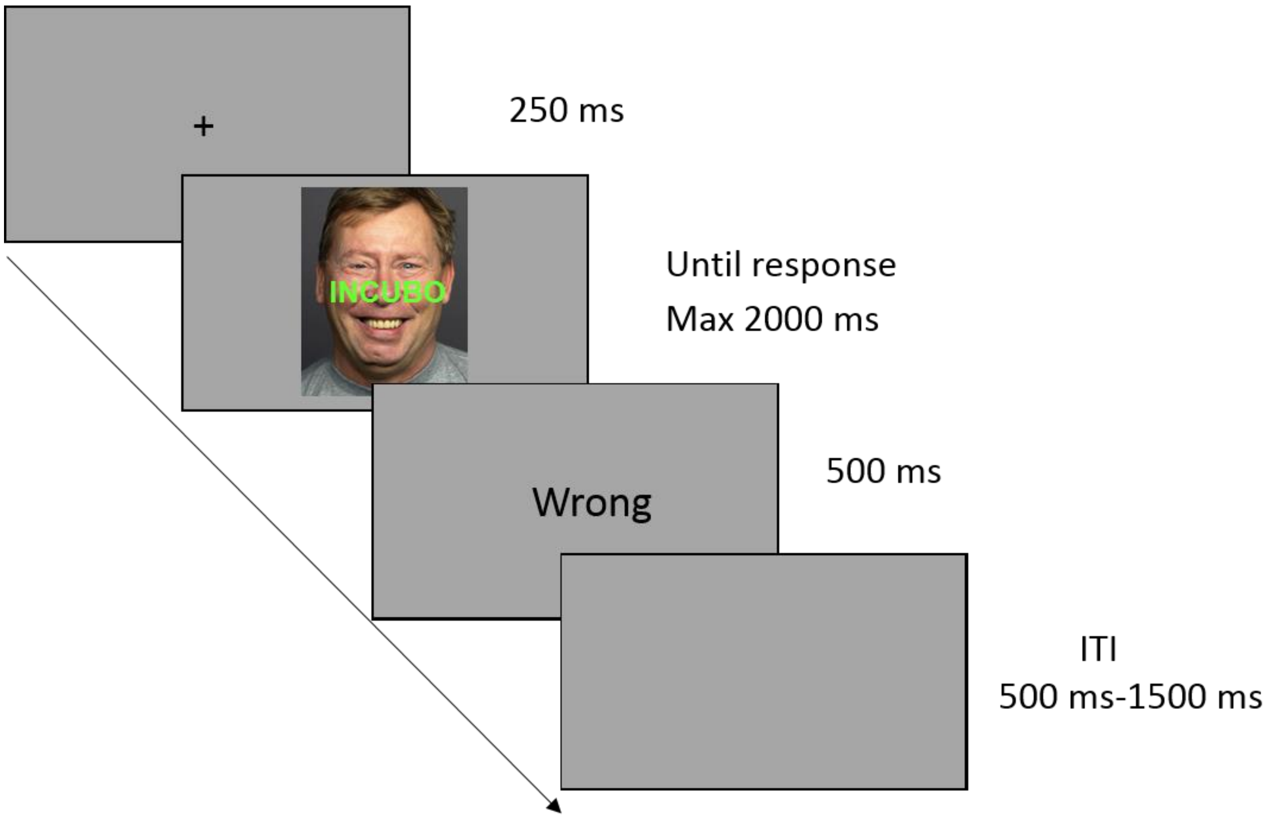

Figure 1: The example shows an Incongruent trial with a negative target-word (*incubo*, Italian for *nightmare*) superimposed onto a happy distractor-face (face ID: 007_m_m_h_b). For example only. Original stimuli are from FACES database. Reprinted with permission.

Participants' task was to respond as fast and accurate as possible to target-words by pressing one of two keys depending on whether the word denoted something positive or negative while ignoring the distractor-faces. Responses were made on the keyboard by pressing the "1" and "2" keys of the numerical keypad, which were appropriately labelled as "Positive" and "Negative". Keys assignment was counterbalanced across participants.

Experimental Design

The experimental design is a 2 (Group: old and young) by 2 (Valence: positive target-words, negative target-words) by 3 (Condition: congruent, incongruent, control) mixed factorial with the first factor between-subjects.

Data Analyses

Trials in which an error was made and with RTs faster than 120 ms or 2.5 SD above the mean were excluded from analyses (5.2% for old and 5.7% for young). Means RTs and accuracy scores – as the proportion of correct responses – were computed for each condition.

Data were analysed using a 2 x 3 x 2 mixed factorial ANOVA with Group (2: old, young) as the between-subjects factor and Condition (3: congruent, control, incongruent) and Valence (2: negative target-words, positive target-words) as the repeated factors. The 3-way interaction was followed-up with individual ANOVAs for each group. All pairwise comparisons are Bonferroni-corrected.

Results

Accuracy: ANOVA results showed that the main effect of Valence was not significant, F (1, 66)= 1.79 p =.673. The main effect of Condition was significant, F (2, 132) = 20.72, $p < .001$, η_p^2= .239. Pairwise comparisons showed that accuracy was greater in the congruent condition (M= .97, SE= .007) than in the control condition (M= .96, SE= .009), p= .002 whereas it was lower in the incongruent (M= .95, SE= .008) compared to the control condition, p= .004. The main effect of Group, F (1, 66) = .23, p = .88 and the 2-way interactions Valence by Group, F (1, 66) = 3.66, p = .06 and Condition by Group, F (2,132) = .2.64, p = .75 were not statistical significant. The Valence by Condition interaction was significant, F (2, 132) = 6.99, $p < .001$, η_p^2= .096. ANOVA results for negative target-words showed a significant main effect of Condition, F (2, 134) = 5.50, p = .005, η_p^2= .076: Accuracy was greater in the congruent (M= .97; SE= .006) than in the control (M= .95; SE= .008) condition, p= .006 whereas it did not differ between incongruent (M= .95; SE= .007) and control conditions, p >.099. ANOVA results for positive target-words showed a significant main effect of Condition, F (2, 134) = 2013, $p < .001$, η_p^2= .303: Accuracy did not differ between congruent (M= .97, SE= .010) and control (M= .97, SE= .011) conditions, p= 212 but it was lower in the incongruent (M= .94, SE= .010) than in the control condition, $p < .001$. Importantly, the 3-way interaction was not significant, F (2, 132) = .39, p = .68. Therefore any potential difference in RTs between old and young adults cannot be due to speed-accuracy trade off.

RTs: ANOVA results showed that the assumption of sphericity was violated as the Mauchly's test was significant for the Valence by Condition interaction, W (2) = .908, p = .043. However, this was not the case for log transformed data, were the Mauchly's test for the Valence by Condition interaction was not significant W (2) = .945, p = .158. Therefore, ANOVAs were conducted on log-transformed data but to aid interpretation, pre-transformed RTs are reported in the descriptives and figures.

The main effect of Valence was significant, F (1, 66) = 29.29, $p < .001$, η_p^2= .307 with slower RTs to negative (M= 950, SE= 27.3) than positive target-words (M= 909, SE= 27.0). The main effect of Condition was significant, F (2, 132) = 52.46, p < .001, η_p^2= .443. Pairwise comparisons showed faster RTs for congruent (M= 909, SE= 26.4) compared to control condition (M= 923, SE= 26.1), p= .004 whereas RTs were slower for incongruent (M= 956, SE= 28.3), compared to both control and congruent conditions, ps <.001. The Valence by Condition interaction was significant, F (2, 132) = 4.29, p <.001, η_p^2= .061 (see Figure 2), which was analysed with individual ANOVAs for each target-words valence.

Insert Figure 2 about here

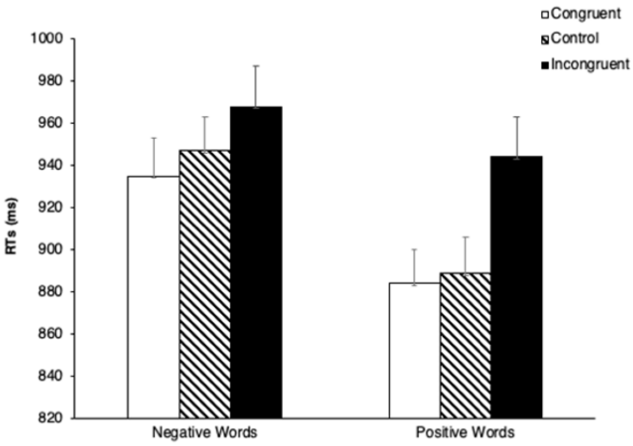

Figure 2: Mean RTs for negative and positive Target-Words as a function of Condition (Congruent, Control and Incongruent). Error bars are +/- Standard Errors of the Means (S.E.M.). Check figure

Results for negative target-words showed a significant main effect of Condition, F (2, 134)= 13.09, p <.001, η_p^2= .163. Pairwise comparisons showed that overall RTs for the congruent condition (M= 935, SE= 27.97) did not differ from the control condition (M= 947, SE = 26.00), p = .075 but RTs for the incongruent condition (M = 968, SE= 28.89) were slower than RTs for the control condition, p= .020. Results for positive target-words showed a significant main effect of

Condition, *F* (2, 134) = 44.73, $p < .001$, $\eta_p^2 = .400$. Pairwise comparisons showed overall faster RTs for the congruent condition (*M* = 884, *SE* = 25.58) compared to the control condition (*M* = 899, *SE* = 27.19), *p* = .025 and slower RTs for the incongruent condition (*M* = 944, *SE* = 28.55) compared to the control condition, $p < .001$. Therefore, overall for negative target-words there was interference and no facilitation whereas for positive target-words there were both interference and facilitation effects.

The main effect of Group was significant, *F* (1, 66) = 118.0, $p < .001$, $\eta_p^2 = .641$ with slower RTs for old (*M*= 1165, *SE*= 37.9) than for young (*M* = 694, *SE*= 37.9) participants. The Valence by Group *F* (1, 66) = 3.14, *p* =.081, and the Condition by Group *F* (2, 132) = 2.23, *p*=.112 interactions were not significant. The 3-way interaction Group by Valence by Condition was significant, *F* (2, 132) = 7.62, $p < .001$, $\eta_p^2 = .103$ (see Table 1).

Table 1 about here

	Old Group				Young Group			
	Congruent	Control	Incongruent	**Overall**	Congruent	Control	Incongruent	**Overall**
Negative	1177 (39.57)	1197 (36.77)	1215 (40.86)	**1196 (38.60)**	694 (39.56)	697 (36.77)	721 (40.86)	**704 (38.60)**
Positive	1094 (36.18)	1116 (38.45)	1191 (40.37)	**1134 (38.04)**	674 (36.18)	682 (38.45)	697 (40.37)	**684 (38.04)**
Overall	**1135 (37.38)**	**1157 (36.95)**	**1203 (40.01)**		**684 (37.38)**	**690 (36.95)**	**709 (40.01)**	

Table 1: Means and SEs for Old and Young adults for negative and positive target-words presented with congruent, control (i.e., neutral scrambled face) and incongruent distractor-faces.

To analyse the 3-way interaction, Facilitation and Interference Effects for negative and positive target-words were computed for older and young adults as a percentage of overall speed according to the formula [(RTCongruent - RT Control)/(RTCongruent + RTControl)/2]*100 for

Facilitation and [(RTIncongruent - RT Control)/(RTIncongruent + RTControl)/2]*100 for Interference (Petrucci & Pecchinenda, 2017). Negative scores indicate facilitation and positive scores interference. Facilitation and Interference effects were analyzed with a 2 (Group: older and young adults) by 2 (Valence: Negative, Positive) mixed factorial ANOVA with the first factor between-subjects.

<u>Facilitation Effects</u>: Results showed that the main effect of Group, F (1, 66)= 1.23, p= .271, the main effect of Valence, F (1, 66)= .012, p= .911, as well as the interaction, F (1, 66)= 2.99, p= .586, were not statistically significant.

<u>Interference Effects</u>: Results showed that the main effect of Group was not significant, F (1, 66)= 1.00, p= .320, but the main effect of Valence was, F (1, 66)= 5.59, p< .021, η_p^2= .078, due to greater interference on positive (M= 1.11, SE= .16) than on negative target-words (M= .54, SE= .19). This effect was qualified by a significant interaction, F (1, 66)= 11.69, p= .001, η_p^2= .150. Follow-up comparisons showed that this was due to older adults showing greater interference from angry distractor-faces on positive target-words (M= 1.65, SE= .24) than from happy distractor-faces on negative target-words (M= .25, SE= .31), t (33)= 3.52, p= .001 whereas for young adults this comparison was not statistically significant, t (33)= .93, p= .361 (see Figure 3).

Insert Figure 3 about here

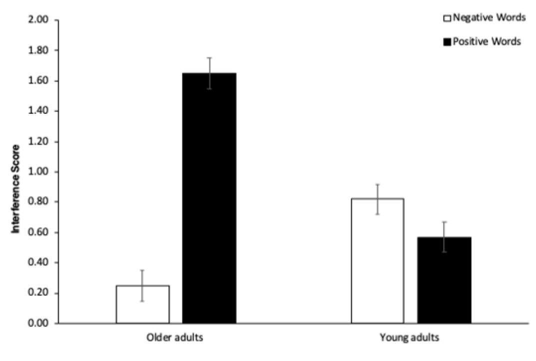

Figure 3: Interference Effects (in ms) for negative and positive target-words for young and old individuals. Error bars are +/- Standard Errors of the Means (S.E.M.).

Finally, we computed the Smallest Effect Size of Interest (SESOI) for the greater interference from angry distractor-faces in older individuals. The effect size of this particular contrast was 1.22, 95%CI [0.47, 1.94] (i.e., a large effect, according to Cohen's effect size conventions). The power to detect this effect in the two present conditions was determined to be 0.98 (critical $t(33) = 2.18$, non-centrality parameter d = 4.39). Based on this, we calculated the smallest effect size of interest $d_{SESOI} = 2.18 * 1.22/ 4.39 = 0.61$, showing that this effect was not due to underpower in the present study.

Internal reliability of the Word-Face Interference Task

Recently, the appropriateness of behavioural tasks to serve as trait-like measures of individual differences has been questioned as the test–retest reliability is low (Enkavi et al., 2019; MacLeod, Grafton, & Notebaert, 2019; Rodebaugh et al., 2016). For instance, behavioural tasks have been used for profiling individual differences in cognitive functions and assess the presence of a bias toward a specific category of emotional stimuli (e.g., bias toward threat in individuals with high anxiety). However, it has also pointed out that this is the case for individual classification of participants (i.e., pre and post-treatment) as there is variability caused by true fluctuations, but it is not the case for group comparisons (MacLeod et al. 2019). That is, what may fluctuate at the individual level can be consistently evident in group averages. In addition, it has been shown that instruments with lower levels of psychometric reliability can consistently reveal group difference in the attributes they measure (De Schryver et al. 2016). Therefore, although the above limitations should not apply to the present data as we are not profiling individuals based on behavioural task performance, we estimated our task's internal reliability using a permutation-based split-half approach (Parsons, 2020) with 5000 random splits. Because both groups were accurate in their responses, the internal reliability was measured by computing within-subjects split-half correlations with Spearman-Brown corrections for mean RTs in each group separately. All calculations were performed using *the split-half* R package (https://github.com/sdparsons/splithalf). Before entering the data into the analysis, we removed error trials and trials below and above 2.5 standard deviations from the mean, within each participant, and within each condition and trial type. The results are displayed in Table 2.

			Raw estimates*		Spearman–Brown corrected estimates	
Group	Condition	N participants analysed	r	95% CI	r_{SB}	95% CI
Older	Congruent	34	0.57	[0.38, 0.72]	0.72	[0.55, 0.84]
	Incongruent	34	0.64	[0.48, 0.78]	0.78	[0.65, 0.87]
	Control	34	0.59	[0.42, 0.75]	0.74	[0.59, 0.85]
Young	Congruent	34	0.72	[0.59, 0.83]	0.84	[0.75, 0.91]
	Incongruent	34	0.77	[0.66, 0.86]	0.87	[0.79, 0.93]
	Control	34	0.66	[0.51, 0.80]	0.80	[0.68, 0.89]

* For compatibility between studies, we report both the raw and the corrected estimates

Table 2. Estimated internal reliability of the WFST task in the present study

As can be seen in Table 2, split–half correlations with Spearman–Brown corrections demonstrated good internal consistency for mean RTs across conditions in our task. The split–half estimates were somewhat lower but still showing adequate internal consistency in the older group.

Discussion

The present study investigated to what extent, under conditions of emotional conflict between task-relevant and to be ignored emotional stimuli, positive or negative information is differentially prioritized and whether prioritization differs between healthy older adults and young adults. The first research question stems from the proposal that negative information – especially that signalling potential threat – is prioritized over other emotional information (e.g., Öhman & Mineka, 2001) and in some cases, it may speed up the resolution of conflict (e.g., Kanske & Kotz, 2010). The latter research question stems from evidence of a bias toward positive information with ageing due to the increased motivation to maintain positive emotions and emotional well-being (e.g., Reed & Carstensen, 2012).

We used a word-face interference task, in which positive and negative words were presented superimposed onto happy or angry faces so that target-words and distractor-faces could be affectively congruent or incongruent. A control condition in which positive and negative target-words were presented superimposed onto scrambled neutral faces was also used to assess facilitation in addition to the interference effects. Participants responded to words based on whether they denoted something positive or negative while ignoring the faces. Findings showed response facilitation when distractor-faces were affectively congruent with target-words and response interference when distractor-faces were affectively incongruent with target-words. Importantly, the pattern of facilitation and interference differed between young and old adults. Whereas young adults showed similar interference from happy and angry distractor-faces, this was not the case for older adults, who showed greater interference from angry distractor-faces. This is an interesting finding when considering that emotional well-being in healthy ageing has been associated to enhanced emotional control with selective prioritization of positive information over negative one (e.g., Isaacowitz et al., 2006). The present findings clearly show that this is not the case for healthy ageing.

That healthy older adults showed greater interference from angry distractor-faces is in stark contrast with a recent study reporting less interference from negative distractors in old individuals when using the word-face interference task (Meléndez et al., 2020). However, this finding was attributed to a double-check strategy for which the activated response on incongruent trials could be rejected if incorrect for the target but to accept as correct the activated response for congruent trials, participants needed to double-check that the response indeed belonged to the target. As this was not the case in the present study, one could argue that a double-check strategy is encouraged by the task used in Meléndez et al. (2020) which relied on identity match between the emotion of the word and that of the distractor-face. That the same strategy was not used for positive stimuli could be due to the fact there are more instances of negative emotions than of positive ones.

It has been pointed out that the ability to process emotional faces, and especially negative ones, declines with age (e.g., Horning, Cornwell, & Davis, 2012). According to this account, older adults have greater difficulty perceiving negative stimuli due to a posterior-anterior shift (Davis et al., 2008). The present findings clearly show that this is not the case for healthy ageing because a difficulty in perceiving negative stimuli entails less interference from angry distractor-faces. Alternatively, it has been suggested that older adults show amygdala and ventromedial prefrontal cortex deficits in the activation to negative stimuli (Allen et al. 2011). In this view, ageing is characterized by an arousal deficit to emotional stimuli. Indeed, Allen, Lien, and Jardin (2017) found that older adults show a negativity bias but only when a stronger negative sound (i.e., scream related to fear) was used (exp. 2), whereas younger adults showed a negativity bias also with a less intense sound (i.e., punch related to anger). Whereas this finding has been interpreted as indicating that older adults needs stronger negative stimuli to show a negativity bias similar to that of younger participants, our study cannot speak to the role of stimulus intensity or arousal in engendering greater interference from emotional distractors. This is because we did not manipulate the arousal level of our distractor-faces (i.e., we used a database with middle age individual to avoid own age bias but for which no arousal ratings are available), albeit angry and happy faces are typically judged to have similar arousal levels (e.g., Goeleven, De Raedt, Leyman & Verschuere, 2008). In contrast, the present findings are in line with studies showing that in visual search tasks older adults, much like young adults, show a threat advantage (e.g., Hahn, Carlson, Singer, & Gronlund, 2006; Mather & Knight, 2006) and that when the task requires processing both negative and positive stimuli, older adults do not show the positivity bias (e.g., Leclerc & Kensinger, 2008; Samanez-Larkin, Robertson, Mikels, Carstensen & Gotlib, 2009).

Considered in this context, the findings of the present study clearly indicate that when both positive and negative information compete for attention, healthy older adults prioritize negative information rather than positive one. We argue that this is because it is more demanding to control the interference from angry distractors than to control for the interference from happy distractors and that this task might have been more taxing for older adults than for younger ones. This account is in keep with evidence that under cognitive load, young adults show greater interference from emotional distractors, and especially angry ones (Petrucci & Pecchinenda, 2017). Moreover, this account is in line with the proposal that older adults require processing resources to exhibit a positive bias and that when task difficulty imposes constraints on such resources, older adults show a negative bias (Mather & Knight, 2005, Isaacowitz et al. 2009).

It should be noted that responses to positive words were overall faster than responses to negative words, which is a typical finding in this field (Leppänen, Tenhunen, & Hietanen, 2003). Whereas it is possible that the slower responses to negative target-words dilute the interference effects from happy distractor-faces, this effect could also be due emotional stimuli – in the present case negative words – triggering attentional control and facilitating conflict resolution (Kanske & Kotz, 2010). Albeit these effects have been observed mainly when emotion is not task-relevant, recently facilitatory effects of emotion on conflict resolution have been demonstrated using a Stroop task with short negative and neutral audio-video clips in old as well as in young adults (Zinchenko, Obermeier, Kanske, Schröger, Villringer, & Kotz, 2017). However, this evidence entails that if emotion –negative and positive – facilitates conflict resolution equally in young and old individuals, then performance at the word-face interference task should be better when target and distractors are affectively congruent (i.e., facilitation) or affectively incongruent (i.e., less interference) compared to the control condition as emotion allows an individual to respond promptly to potential threat or reward situations (Pessoa, 2009).

Finally, we exclude that the present findings could be due solely to faces being processed faster than words, albeit we acknowledge that this factor contributes to enhance the interference effect from emotional distractor-faces (i.e., see Beall & Herbert, 2008). In fact, if that was the case, task-irrelevant faces should have engendered interference independently of their emotional valence for both old and young adults. By contrast, the finding that only angry faces produced an interference effect on positive words, and not vice versa, rules out the possibility that our interference effect depended solely on the faster processing of emotional faces compared to emotional words and indicates that, under emotional conflict, older adults exhibit a negative bias.

Future studies should help disentangling to what extent evidence that emotion facilitates conflict resolution generalizes also to other tasks besides the Stroop task. In fact, whether emotion enhances or reduces the conflict yielded by two emotional stimuli that compete for attention is far from being settled when there is evidence that emotions can speed up conflict resolution, but also that emotions interfere with attentional control (Lim, Padmala, & Pessoa, 2008), and increase alertness, which impairs conflict resolution (Callejas, Lupiáñez, & Tudela, 2004). However, this was not the case in the present study, as angry distractor-faces clearly engendered greater emotional conflict in older adults.

It is important to note that, past studies conducted using the word-face interference task have rarely assessed both facilitation and interference effects because to do so requires using a control condition, which in our case was a scrambled distractor-face. Only by assessing facilitation and interference effects allows to disentangle to what extent positive or negative information is prioritized over the other and which emotional information is more difficult to inhibit/control. That in the present study facilitation effects for congruent trials were small indicates that participants complied with tasks instruction and ignored the task-irrelevant distractors. This account is in line with evidence linking the activity of the dorso-lateral prefrontal cortex (DLPFC) involved in cognitive control to reduced interference from distractors. Indeed, Banich, Smolker, Snyder, Lewis-Peacock, Godinez, Wager, and Hankin (2019) using a word-face interference task similar to the one used in the present study, found that increased DLPFC activity was associated with reduced processing of distractor-faces, for both congruent and incongruent trials. In contrast, the larger interference effects for incongruent trials suggests that angry distractors are more difficult to ignore, especially for older adults. That to ignore angry distractor-faces requires more cognitive resources than ignoring happy ones has been recently shown in a tDCS study by De Luca, Petrucci, Monachesi, Lavidor, and Pecchinenda (2020) using the word-face interference task. They found that potentiating the *l*DLPFC via anodal stimulation reduced interference from emotional distractors, but only when participants had already gained experience with the task. Importantly, having already performed the task only eliminated facilitation effects for positive stimuli.

In summary, the findings of the present study clearly show that when using the word-face interference task, the pattern of emotion prioritization between young adults and healthy old adults is different. Young individuals equally prioritize happy and angry distractor-faces and the interference from these distractors is comparable. In contrast, healthy older adults prioritize more angry distractor-faces, which engender greater interference. Although this finding may appear to be at odds with the established literature showing a positivity bias in ageing, it is well possible that the positivity bias applies to more elaborative and less implicit processes.

Compliance with Ethical Standards:

Funding: This study was funded by Ministero dell'Istruzione, dell'Universitá, della Ricerca (MIUR; grant number RG11916B88615C08) awarded to AP, by a Thesis Studentiship from the Faculty of Medicine and Psychology, Sapienza University awarded to GV and by a phd studenthip in Behavioural Neuroscience from the Ministero dell'Istruzione, dell'Universitá, della Ricerca (MIUR) awarded to FDL.

Conflict of Interest: The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the Departmental Ethics Committee, which granted approval, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent: Written informed consent was obtained from all individual participants included in the study.

Acknowledgments: The study with older adults was part of the Master thesis submitted by GV. The authors thanks Drs. Monachesi and Petrucci for help with some of the stimuli used in the studies.

References

Allen, P. A., Kaut, K. P., Baena, E., Lien, M.C., & Ruthruff, E. (2011). Individual differences in positive affect moderate age- related declines in episodic long-term memory. *Journal of Cognitive Psychology*, 23, 768–779. doi.org/10.1080/20445911.2011.570254

Allen, P.A., Lien, M.C., & Jardin, E. (2017). Age-related emotional bias in processing two emotionally valenced tasks. *Psychological Research*, 81:289–308, doi 10.1007/s00426-015-0711-8

Ashley, V., & Swick, D. (2009). Consequences of emotional stimuli: age differences on pure and mixed blocks of emotional Stroop. *Behavioral and Brain Functions*, *5*, 14. doi:10.1186/1744-9081-5-14.

Augustí, A. I., Satorres, E., Pitarque, A., & Meléndez, J. C. (2017). An emotional Stroop task with faces and words. A comparison of young and older adults. *Consciousness and Cognition*, *53*, 99-104. doi:10.1016/j.concog.2017.06.010.

Baggott, S., Palermo, R., & Fox, A. M. (2011). Processing emotional category congruency between emotional facial expressions and emotional words. *Cognition and Emotion*, *25*(2), 369-379. doi:10.1080/02699931.2010.488945.

Bradley, M.M., & Lang, P.J. (1999). Affective norms for English words (ANEW): Instruction manual and affective ratings. (Technical Report C-1).Gainesville: University of Florida , Center for Research in Psychophysiology.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzedoorn, M. H. (2007). Threat-related attentional bias in anxious and non-anxious individuals: a meta-analytic study. *Psychological Bulletin*, *133*(1), 1-24. doi:10.1037/0033-2909.133.1.1.

Beall, P. M., & Herbert, A. M. (2008). The face wins: Stronger automatic processing of affect in facial expressions than words in a modified Stroop task. *Cognition and Emotion*, *22*(8), 1613-1642. doi:10.1080/02699930801940370.

Callejas, A., Lupiáñez, J., & Tudela, P. (2004) The three attentional networks: On their independence and interactions, *Brain and Cognition*, 54, 225-227, doi.org/10.1016/j.bandc.2004.02.012.

Campbell, J. I., & Thompson, V. A. (2012). MorePower 6.0 for ANOVA with relational confidence intervals and Bayesian analysis. *Behavior Research Methods*, *44*(4), 1255–1265. doi:10.3758/s13428-012-0186-0.

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. American Psychologist, 54(3), 165–181. https://doi.org/10.1037/0003-066X.54.3.165

Carver, C. S., & Harmon-Jones, E. (2009). Anger is an approach-related affect: evidence and implications. *Psychological bulletin*, *135*(2), 183–204. doi:10.1037/a0013965.

Chechko, N., Augustin, M., Zvyagintsev, M., Schneider, F., Habel, U., & Kellermann, T. (2013). Brain circuitries involved in emotional interference task in major depression disorder. *Journal of Affective Disorders*, *149*(1-3), 136–145. doi:10.1016/j.jad.2013.01.013

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and Stimulus-driven attention in the brain. *Nature reviews. Neuroscience*, *3*(3), 201-215. doi:10.1038/nrn755.

Corbetta, M., Patel, G., & Shulman, G. L. (2008). The reorienting system of the human brain: from environment to the theory of mind. *Neuron*, *58*(3), 306-324. doi:10.1016/j.neuron.2008.04.017.

Simon W. Davis, Nancy A. Dennis, Sander M. Daselaar, Mathias S. Fleck, Roberto Cabeza, Qué PASA? The Posterior–Anterior Shift in Aging, Cerebral Cortex, 18, 5, 1201–1209 https://doi.org/10.1093/cercor/bhm155

De Luca, F., Petrucci, M., Monachesi, B., Lavidor, M., & Pecchinenda, A. (2020). Asymmetric Contributions of the Fronto-Parietal Network to Emotional Conflict in the Word–Face Interference Task. *Symmetry*,12, 10, 1701; https://doi.org/10.3390/sym12101701

De Schryver, M., Hughes , S., Rosseel , Y., & De Houwer, J. (2016). Unreliable Yet Still Replicable: A Comment on LeBel and Paunonen (2011). *Frontiers in Psychology*, 13, https://doi.org/10.3389/fpsyg.2015.02039

Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience, 18*, 193-222. doi: 10.1146/annurev.ne.18.030195.001205.

Ebner, N. C., Riediger, M., & Lindenberger, U. (2010). FACES--a database of facial expressions in young, middle-aged, and older women and men: development and validation. *Behavior Research Methods*, *42*(1), 351–362. doi:10.3758/BRM.42.1.351.

Egner, T., Ektin, A., Gale, S., & Hirsch, J. (2008). Dissociable neural systems resolve conflict from emotional versus nonemotional distracters. *Cerebral Cortex*, *18*(6), 1475-1484. doi:10.1093/cercor/bhm179.

Ektin, A., Egner, T., Peraza, D. M., Kandel, E. R., & Hirsch, J. (2006). Resolving emotional conflict: a role for the rostral anterior cingulate cortex in modulating activity in the amygdala. *Neuron*, *51*(6), 871-882. doi:10.1016/j.neuron.2006.07.029.

Enkavi, A. Z., Eisenberg, I. W., Bissett, P. G., Mazza, G. L., MacKinnon, D. P., Marsch, L. A., & Poldrack, R. A. (2019). Large-scale analysis of test-retest reliabilities of self-regulation measures. *Proceedings of the National Academy of Sciences*, 116(12), 5472-5477. https://doi.org/10.1073/pnas.1818430116.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception and Pyschophysics*, *16*(1), 143-149. doi:10.3758/BF03203267.

Fairfield, B., Ambrosini, E., Mammarella, N., & Montefinese, M. (2017). Affective Norms for Italian Words in Older Adults: Age Differences in Ratings of Valence, Arousal and Dominance. *PloS one*, *12*(1), e0169472. doi:10.1371/journal.pone.0169472.

Fernandes, A., Garcia-Marques, T., Prada, M., & Martins, J. (2019). Emotional interference in isolation and in others' presence. *Current Psychology: A Journal for Diverse Perspectives on Diverse Psychological Issues.* doi:10.1007/s12144-019-00534-0.

Frühholz, S., Jellinghaus, A., & Herrmann, M., (2011)Time course of implicit processing and explicit processing of emotional faces and emotional words, *Biological Psychology*, 87:2, 265-274, https://doi.org/10.1016/j.biopsycho.2011.03.008.

Goeleven, E., De Raedt, R., Leyman, L., & Verschuere, B. (2008) The Karolinska Directed Emotional Faces: A validation study, *Cognition and Emotion*, 22:6, 1094-1118, doi: 10.1080/02699930701626582

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*. https://doi.org/10.1016/j.actpsy.2006.01.008

Haas, B. W., Omura, K., Constable, R. T., & Canli, T. (2006). Interference produced by emotional conflict associated with anterior cingulate activation. *Cognitive, Affective and Behavioral Neuroscience*, *6*(2), 152-156. doi:10.3758/cabn.6.2.152.

Horning S.M., Cornwell R.E., Davis H.P. (2012) The recognition of facial expressions: An investigation of the influence of age and cognition. Aging, Neuropsycholy & Cognition 19, 657- 676.

Hu, Z., Liu, H., Weng, X., & Northoff, G. (2012). Is there a valence-specific pattern in emotional conflict in major depressive disorder? An exploratory psychological study. *PloS one*, *7*(2), e31983. doi:10.1371/journal.pone.0031983.

Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006). Is there an age-related positivity effect in visual attention? A comparison of two methodologies. *Emotion*, *6*(3), 511-516. doi:10.1037/1528-3542.6.3.511.

Kanske, P., & Kotz, S. A. (2010). Modulation of early conflict processing: N200 responses to emotional words in a flanker task. *Neuropsychologia*, *48*(12), 3661–3664. doi:10.1016/j.neuropsychologia.2010.07.021.

Kauschke, C., Bahn, D., Vesker, M., & Schwarzer, G. (2019). The Role of Emotional Valence for the Processing of Facial and Verbal Stimuli-Positivity or Negativity Bias? *Frontiers in Psychology*, *10*, 1654. doi:10.3389/fpsyg.2019.01654.

Kohn, N., Hermans, E. J., & Fernández, G. (2017). Cognitive benefit and cost of acute stress is differentially modulated by individual brain state. *Social Cognitive and Affective Neuroscience*, *12*(7), 1179-1187, doi:10.1093/scan/nsx043.

Kunzmann, U., Kappers, K., & Wrosch, C. (2014). Emotional aging: a discrete emotions perspective. *Frontiers in Psychology*, 16, doi.org/10.3389/fpsyg.2014.00380

Krug, M. K., & Carter C. S. (2012). Proactive and reactive control during emotional interference and its relationship to trait anxiety. *Brain Research*, *1481*, 13-36. doi:10.1016/j.brainres.2012.08.045.

Lang, P., & Bradley, M. M. (2010). Emotion and the motivational brain. *Biological Psychology, 84*(3), 437-450. doi:10.1016/j.biopsycho.2009.10.007.

Leclerc, C. & Kensinger, E.A. (2008) Effects of age on detection of emotional information. *Psychology and Aging*, 23, 209-215. DOI: 10.1037/0882-7974.23.1.209.

Leppänen, J. M., Tenhunen, M., & Hietanen, J. K. (2003). Faster choice-reaction times to positive than to negative facial expressions: The role of cognitive and motor processes. *Journal of Psychophysiology*, *17*(3), 113–123. https://doi.org/10.1027/0269-8803.17.3.113.

Lim, S-L., Padmala, S. & Pessoa, L. (2008). Affective learning modulates spatial competition during low-load attentional conditions, *Neuropsychologia*, 46, 1267-1278, doi.org/10.1016/j.neuropsychologia.2007.12.003.

MacLeod, C., Grafton, B., & Notebaert, L. (2019). Anxiety-Linked Attentional Bias: Is It Reliable? *Annual Review of Clinical Psychology*, 15(1), 529-554. https://doi.org/10.1146/annurev-clinpsy-050718-095505.

Mather, M. & Carstensen, L.L. (2003) Aging and Attentional Biases for Emotional Faces. Psychological Science, 14, 409-415, https://doi.org/10.1111/1467-9280.01455.

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*, 61, 57, doi.org/10.1093/geronb/61.1.P54.

Meléndez, J. C., Satorres, E., & Oliva, I. (2020). Comparing the Effect of Interference on an Emotional Stroop Task in Older Adults with and without Alzheimer's Disease. *Journal of Alzheimer's disease*, *73*(4), 1445–1453. doi:10.3233/JAD-190989.

Molina, S., Borkovec, T. D., Peasley, C., & Person, D. (1998). Content analysis of worrisome streams of consciousness in anxious and dysphoric participants. *Cognitive Therapy and Research*, *22*(2), 109–123. doi:10.1023/A:1018772104808.

Montefinese, M., Ambrosini, E., Fairfield, B., & Mammarella, N. (2014). The adaptation of the Affective Norms for English Words (ANEW) for Italian. *Behavior Research Methods*, *46*(3), 887–903. doi:10.3758/s13428-013-0405-3.

Monti, J. M., Weintraub, S., & Egner, T. (2010). Differential age-related decline in conflict-driven task-set shielding from emotional versus non-emotional distracters. *Neuropsychologia*, *48*(6), 1697-1706. doi: 10.1016/j.neuropsychologia.2010.02.017.

Morani, S., Pricci, D., & Sanavio, E. (1999). “Penn State Worry Questionnaire” e “Worry Domains Questionnaire”: Presentazione delle versioni italiane e analisi di fedeltà. *Psicoterapia Cognitiva e Comportamentale*, *5,* 195-209.

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, *53*(4), 695–699. doi:10.1111/j.1532-5415.2005.53221.x.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (2004). The University of South Florida free association, rhyme, and word fragment norms. *Behavior Research Methods, Instruments, & Computers*, *36*(3), 402–407. doi:10.3758/bf03195588.

Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: toward an evolved module of fear and fear learning. *Psychological Review*, *108*(3), 483- 522. doi:10.1037/0033-295x.108.3.483.

Parsons, S., Kruijt, A.-W., & Fox, E. (2019). Psychological Science Needs a Standard Practice of Reporting the Reliability of Cognitive-Behavioral Measurements. *Advances in Methods and Practices in Psychological Science*, 251524591987969. https://doi.org/10.1177/2515245919879695

Pecchinenda, A., & Heil, M. (2007). Role of working memory load on selective attention to affectively valent information. *European Journal of Cognitive Psychology*, *19*(6), 898-909, doi:10.1080/09541440601095388.

Pecchinenda, A., Ferlazzo, F., & Lavidor, M. (2015). Modulation of selective attention by polarity-specific tDCS effects. *Neuropsychologia*, *68*, 1-7. doi:10.1016/j.neuropsychologia. 2014.12.023.

Peressotti, F., Pesciarelli, F., & Job, R. (2002). Le associazioni verbali PD-DPSS: norme per 294 parole. *Giornale Italiano di Psicologia, Rivista Trimestrale*, *1*/2002, 153-172. doi:10.1421/1223.

Pessoa, L. (2009). How do emotion and motivation direct executive control? *Trends in Cognitive Sciences*, *13*(4), 160-166. doi:10.1016/j.tics.2009.01.006.

Petrucci, M., & Pecchinenda, A. (2017). The role of cognitive control mechanisms in selective attention towards emotional stimuli. *Cognition and Emotion*, *31*(7), 1480-1492. doi:10.1080/02699931.2016.1233861.

Pourtois, G., Schettino, A., & Vuilleumier, P. (2013). Brain mechanisms for emotional infleunces on perception and attention: What is magic and what is not. *Biological Psychology*, *92*(3), 492-512. doi:10.1016/j.biopsycho.2012.02.007.

Preston, S. D., & Stansfield, R. B. (2008). I know how you feel: Task-irrelevant facial expressions are spontaneously processed at a semantic level. *Cognitive, Affective & Behavioral Neuroscience*, *8*(1), 54-64. doi:10.3758/cabn.8.1.54.

Redish (2012) https://www.usability.gov/sites/default/files/documents/guidelines_book.pdf

Reed, A. E., & Carstensen, L. L. (2012). The theory behind the age-related positivity effect. *Frontiers in Psychology, 3*, 339. doi:10.3389/fpsyg.2012.00339.

Rodebaugh, T. L., Scullin, R. B., Langer, J. K., Dixon, D. J., Huppert, J. D., Bernstein, A., Zvielli, A., & Lenze, E. J. (2016). Unreliability as a threat to understanding psychopathology: The cautionary tale of attentional bias. *Journal of Abnormal Psychology*, 125(6), 840-851. https://doi.org/10.1037/abn0000184

Roemer, L., Molina, S., & Borkovec, T. D. (1997). An Investigation of Worry Content among Generally Anxious Individuals. *Journal of Nervous & Mental Disease*, *185*(5), 314–319. doi:10.1097/00005053-199705000-00005.

Ruffman, T., Henry, J.D., Livingston, 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 81,https://doi.org/10.1016/j.neubiorev.2008.01.001.

Samanez-Larkin, G.R., Robertson, E.R., Mikels, J.A., Carstensen, L.L., & Gotlib, I.H. (2009). Selective attention to emotion in the aging brain. *Psychology Aging*. 24, 519–529. doi: 10.1037/a0016952.

Santangelo, G., Siciliano, M., Pedone, R., Vitale, C., Falco, F., Bisogno, R., Siano, P., Barone, P., Grossi, D., Santangelo, F., & Trojano, L. (2015). Normative data for the Montreal Cognitive Assessment in an Italian population sample. *Neurological sciences: official journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology*, *36*(4), 585–591. doi:10.1007/s10072-014-1995-y.

Sasse, L. K., Gamer, M., Büchel, C., & Brassen, S. (2014). Selective control of attention supports the positivity effect in aging. *PLoS one*, *9*(8), e104180. doi:10.1371/journal.pone.0104180.

Scheibe, S., & Carstensen, L. L. (2010). Emotional aging: recent findings and future trends. The *Journals of Gerontology, Series B, Psychological Sciences and Social Sciences*, *65B*(2), 135-144. doi:10.1093/geronb/gbp132.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). E-Prime (Version 2.0). [Computer software and manual]. *Pittsburgh, PA: Psychology Software Tools Inc.*

Stenberg, G., Wiking, S., & Dahl, M. (1998). Judging words at face value: Interference in a word processing task reveals automatic processing of affective facial expressions. *Cognition and Emotion*, *12*(6), 755-782. doi:10.1080/026999398379420.

St. Jacques, P.L., Bessette-Symons, B., & Cabeza, R. (2009). Functional neuroimaging studies of aging and emotion: Fronto-amygdalar differences during emotional perception and episodic memory. *Journal of International Neuropsychological Society*, 15:6: 819–825. doi: 10.1017/S1355617709990439.

Strand, M., Oram, M. W., & Hammar, Å. (2013). Emotional information processing in major depressions remission and partial remission: Faces come first. *Applied Neuropsychology. Adult*, *20*(2), 110-119. doi:10.1080/09084282.2012.670159.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*(6), 643-662. doi:10.1037/h0054651.

Theeuwes, J. (1994). Stimulus-driven capture and attentional set: Selective search for color and visual abrupt onsets. *Journal of Experimental Psychology: Human Perception and Performance*, *20*(4), 799-806. doi:10.1037/0096-1523.20.4.799.

Vuilleumier, P. (2005). How brains beware: Neural mechanisms of emotional attention. *Trends in Cognitive Sciences, 9*(12), 585-594. doi:10.1016/j.tics.2005.10.011.

Wilkowski, B. M., & Meier, B. P. (2010). Bring it on: Angry facial expressions potentiate approach-motivated motor behavior. *Journal of Personality and Social Psychology, 98*(2), 201–210. doi:10.1037/a0017992.

Yang, Q., Wang, X., Yin, S., Zhao, X., Tan, J., & Chen, A. (2016). Improved emotional conflict control triggered by the processing priority of negative emotion. *Scientific Reports*, *6*, 24302. doi:10.1038/srep24302.

Zinchenko, A., Obermeier, C., Kanske, P., Schröger, E., Villringer, A. & Kotz, S.A. (2017). The Influence of Negative Emotion on Cognitive and Emotional Control Remains Intact in Aging, *Frontiers in Aging Neuroscience*, 9, 349 DOI:10.3389/fnagi.2017.00349.

Zhu, X. R., Zhang, H. J., Wu, T. T., Luo, W.B., & Luo, Y.J. (2010). Emotional conflict occurs at an early stage: Evidence from the emotional face-word Stroop task. *Neuroscience letters*, *478*(1), 1-4. doi:10.1016/j.neulet.2010.04.036.

Appendix

List of Target-Words: dolore (pain), fascino (charme), gloria (glory), disastro (disaster), debito (debt), salute (health), canzone (song), castigo (punishment), ulcera (ulcer), trionfo (triumph), viaggio (travel), ciclone (cyclone), ricatto (blackmail), insulto (insult), trauma (trauma), vittima (victim), incubo (nightmare), caduta (fall), malaria (malaria) danno (damage), passione (passion), musica (music), fiducia (trust), natura (nature), speranza (hope), rispetto (respect), famiglia (family), bacio (kiss), denaro (money), angelo (angel), profumo (perfume), invito (invitation), regalo (gift), talento (talent), applauso (applause), cucciolo (puppy), divorzio (divorce), scandalo (scandal), litigio (quarrel), peccato (sin), problema (trouble), sbaglio (mistake), malizia (malice), palude (swamp), giustizia (justice), bellezza (beauty), aurora (dawn), tramonto (sunset), vittoria (victory), conforto (comfort), vacanza (holiday), saluto (greeting), guerra (war), inganno (deceipt), schiavo (slave), miseria (misery), tortura (torture), pressione (pressure), tragedia (tragedy), processo (lawsuit).

List of Distractor-Faces

16 angry faces: 026_m_m_a_a, 056_m_m_a_b, 051_m_m_a_b, 092_m_m_a_b, 094_m_m_a_b, 104_m_m_a_b, 108_m_m_a_a, 116_m_m_a_a, 011_m_f_a_a, 052_m_f_a_b, 093_m_f_a_a, 111_m_f_a_b, 113_m_f_a_a, 117_m_f_a_b, 157_m_f_a_b, 168_m_f_a_b.

16 happy faces: 014_m_m_h_a, 032_m_m_h_a, 045_m_m_h_b, 077_m_m_h_b, 126_m_m_h_b, 007_m_m_h_b, 165_m_m_h_a, 179_m_m_h_b, 035_m_f_h_a, 043_m_f_h_a, 061_m_f_h_b, 064_m_f_h_a, 073_m_f_h_b, 097_m_f_h_a, 122_m_f_h_b, 138_m_f_h_b.

16 neutral faces for scrambles: : 058_m_m_n_a, 068_m_m_n_a, 082_m_m_n_a, 169_m_m_n_a, 136_m_m_n_b, 149_m_m_n_b, 155_m_m_n_b, 159_m_m_n_b, 006_m_f_n_a,

019_m_f_n_b, 029_m_f_n_a, 050_m_f_n_a, 084_m_f_n_a, 128_m_f_n_a, 156_m_f_n_a, 180_m_f_n_a .

12 faces for practice: 070_m_m_a_b, 038_m_m_a_b, 080_m_f_a_b, 139_m_f_a_a, 070_m_m_h_b, 038_m_m_h_b, 080_m_f_h_b, 139_m_f_h_b, 142_m_m_n_a, 142_m_m_n_b, 103_m_f_n_a, 103_m_f_n_b.