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Older adults' Attentional Deployment: Differential Gaze Patterns for Different Negative Mood States

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Abstract

Background and Objectives. Older adults are characterized by an attentional preference for positive over negative information. Since this positivity effect is considered to be an emotion regulation strategy, it should be more pronounced when emotion regulation is needed. In contrast to previous studies that focused on the effects of sad mood on attention, we used a stressor to activate emotion regulation and evaluate the effects of different types of mood state changes. Moreover, we evaluated mood effects on attentional processes using a paradigm that allows disentangling between different attentional engagement and disengagement processes. Methods. Sixty older adults were randomly assigned to receive a stressor or a control task. Before and after this manipulation, mood state levels (happy, sad, nervous, calm) were assessed. Next, attentional processing of happy, sad, and angry faces was investigated using an eye-tracking paradigm in which participants had to either engage their attention towards or disengage their attention away from emotional stimuli.

Results. Changes in different mood state levels were associated with different attentional disengagement strategies. As expected, older adults who increased in sad mood level showed a larger positivity effect as evidenced by a longer time to disengage attention from happy faces. However, older adults who received the tension induction and who decreased in calm mood level were characterized by longer times to disengage attention from sad faces.

Limitations. The stressor was only partially effective as it led to changes in calm mood, but not in nervous mood.

Conclusions. These results suggest that older adults may deploy a positivity effect in attention (i.e., longer times to disengage from positive information) in order to regulate sad mood, but that this effect may be hampered during the confrontation with stressors.

Key words: older adults, attentional bias, emotion regulation, eye tracking, negative mood

1. Introduction

Although aging is associated with declines in several areas of functioning, not all functions deteriorate. Current research points towards age-related improvements in emotion regulation (e.g. Urry & Gross, 2010). Emotion regulation is the ability to influence the experience and/or expression of emotions, and it is a key factor determining emotional wellbeing (Gross, 1998). Therefore, age-related improvements in emotion regulation abilities may help to understand unexpected results on wellbeing in older adults. In contrast to what might be expected as a result of the increasing amount of loss experiences in late life, studies have reported decreased negative affect and even increased positive affect in older adults (Carstensen et al., 2011; Charles, Reynolds, & Gatz, 2001). These relatively high levels of emotional wellbeing are thought to result from an improved ability to regulate emotions with aging.

One of the most prominent theories on aging, the socio-emotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999), proposes that older adults allocate more resources towards emotion regulation to achieve and maintain high levels of emotional wellbeing. One possible way to achieve this is by selectively attending to positive over negative information in the environment (see Sanchez & Vazquez, 2014). This pattern of attentional deployment has been conceptualized as a key strategy of emotion regulation (Gross, 1998). Importantly, this pattern of attentional deployment, conceptualized as the 'positivity effect' (Carstensen & Mikels, 2005), is predicted to increase with age, acting as a mechanism of emotion regulation to maintain emotional wellbeing in older adults.

To investigate this age-related positivity effect, several studies have focused on age-related differences in attentional processing of emotional stimuli. Previous studies have shown that, in contrast to younger adults, older adults are characterized by larger attentional preferences for positive than negative stimuli (Reed, Chan & Mikels, 2014; Scheibe &

Carstensen, 2010). However, other studies have failed to replicate this positivity effect in older adults' emotional attention (Murphy & Isaacowitz, 2008; Steinmetz, Muscatell, & Kensinger, 2010). In an attempt to clarify mixed findings, it has been suggested that the positivity effect in older adults would be more pronounced under certain conditions (e.g. Reed et al., 2014; Urry & Gross, 2010). Given that the positivity effect in attention is thought to reflect an emotion regulation strategy, it has been proposed that it should become more pronounced under conditions where emotion regulation is needed, such as during increased negative mood (Isaacowitz & Blanchard-Fields, 2012).

Recent research has started focusing on the interplay between mood and attentional deployment in older adults. Demeyer and De Raedt (2013) found that inter-individual differences in negative emotions in older adults were related to attentional biases measured by an exogenous cueing task. Older adults who reported higher levels of anxiety showed the largest positivity effect, as evidenced by faster attentional avoidance of negative stimuli. Isaacowitz, Toner, Goren, and Wilson (2008) induced a negative mood state in a sample of older adults before assessing attention patterns to different emotional stimuli with eye tracking. Older adults at high levels of negative mood spent more time looking towards positive stimuli and less time looking towards negative stimuli. Therefore, these gaze patterns may serve as an emotion regulation mechanism (Isaacowitz et al., 2008). In line with this idea, Isaacowitz and Choi (2012) demonstrated a link between older adults' attentional patterns and subsequent recovery from negative mood states. When confronted with a negative film clip, older adults who looked less at the negative content were faster in regulating the induced negative mood state. Thus, an increased negative mood may serve as a signal that more effort is needed to reach an optimal level of emotional wellbeing. As a result, older adults would deploy a positivity effect in emotional attention (i.e., selectively attending to positive over negative information) in order to regulate negative mood states.

Although initial evidence points towards the positivity effect as an emotion regulation strategy, further research is required. First, previous studies investigating this effect have focused on emotional attention after inducing sad mood, whereas the presence of a positivity effect in response to other types of negative mood states remains unclear. It has been suggested that older adults are less emotionally reactive to stress as a result of improved emotion regulation strategies (Neupert, Almeida, & Charles, 2007). However, it also has been suggested that once experiencing greater levels of physical arousal older adults have greater difficulties in recovering from arousal increases (Charles, 2010). The Strength and Vulnerability Integration (SAVI) model (Charles, 2010) posits that age-related changes in emotion regulation are not only characterized by enhancement in emotion regulation strategies that help to limit the exposure to negative information, but also by increasing difficulties with modulating high arousal and stress. Thus, not all negative mood states may lead to the successful use of attentional strategies in emotion regulation. However, to the best of our knowledge, no studies have investigated the influence of mood states that are linked to the reactivity to stressors (i.e., increased nervousness, reduced calmness), as opposite to sad mood state, on older adults' attentional deployment. Second, studies analyzing the interplay between mood states and attentional deployment have mainly focused on attention during naturalistic free viewing, finding evidence for prolonged attentional processing of positive compared to negative information (e.g. Isaacowitz et al., 2008). However, attention research stresses the importance of differentiating between interrelated components of attention (Posner & Cohen, 1984), such as attentional engagement (i.e., directing attention towards stimuli) and attentional disengagement (i.e., shifting attention away from stimuli). It has been indicated that these distinct attentional processes can play a role during the regulation of emotions (e.g., Sanchez, Vazquez, Gomez & Joormann, 2013*a*; Sanchez, Vazquez, Marker, LeMoult & Joormann, 2013*b*). For instance, depressed individuals, known for difficulties with emotion regulation, do

not differ from control groups in directing attention to negative information, but they do exhibit difficulties in disengaging once this negative information has captured their attention (for an overview, see De Raedt & Koster, 2010). Since the tasks used in previous studies (e.g. Isaacowitz et al., 2008) do not allow disentangling these two components involved in overt attentional processing, it remains unclear whether the prolonged attentional processing of positive compared to negative information found in these studies results from a faster engagement to positive information, slower disengagement from positive stimuli, and/or faster disengagement from negative stimuli. Therefore, studies using tasks that allow disentangling these two differential attentional components are needed. Third, several types of negative stimuli (e.g. angry and sad faces) have been used to investigate preferences for positive over negative stimuli. Although former studies have shown that the positivity effect reflects an attention bias away from sad faces (e.g. Demeyer & De Raedt, 2013, Mather & Carstensen, 2003), there are also several studies in which a bias away from angry faces was found (e.g. Isaacowitz, Wadlinger, Goren, & Wilson, 2006, Mather & Carstensen, 2003). These findings highlight the importance of including different types of negative stimuli in order to investigate whether attentional engagement and disengagement processes differ in response to different types of stimuli.

The aim of the current study was to clarify these questions by investigating the conditions (i.e., different mood states: happy, sad, nervous, calm; different emotional information: happy, angry, sad) that determine the occurrence of the positivity effect in older adults and the specific processes underlying such attentional deployment pattern (i.e., faster engagement towards positive information, slower disengagement from positive information, and/or faster disengagement from negative information). In contrast to previously found associations between sad/happy mood states and attentional deployment, we aimed to extend the knowledge on the influence of mood on the positivity effect by clarifying the influence of

mood states linked to the reactivity towards stressors in older adults' attentional deployment. Therefore, this study represents a first pilot study using a stressor (i.e., an unsolvable task) to investigate the potential role of mood state changes associated to the reactivity towards stressors (i.e., an increase in nervousness, decrease in calmness), as opposite to sad mood state changes, in older adult's emotional attention processes. A group of older adults receiving this stressor and a control group (who did not have to complete the unsolvable task) performed an attention task based on eye-tracking, the engagement-disengagement task (Sanchez et al., 2013*b*), to obtain direct measures of attentional engagement towards and attentional disengagement from emotional faces.

We expected that, compared to the control condition, the stressor would mainly generate a decrease in calm mood state and an increase in nervous mood state. Furthermore, we expected that mood state changes induced by the stressor would influence subsequent attentional deployment to emotional information. According to the affective contrast theory (Manstead, Wagner, & MacDonald, 1983), the salience of temporal mood states depends on their contrast with the preceding mood state levels. Therefore, not current mood state per se, but specifically changes in mood would enhance the need for emotion regulation. Consistent with this model and in line with previous studies (Isaacowitz, Toner, & Neupert, 2009; Sanchez et al., 2013*a*), we investigated not only between-group differences in subsequent attentional deployment, but also specific linear relationships between inter-individual changes in mood states and attentional deployment. We hypothesized that induced changes in mood state (e.g. increased nervous mood, decreased calm mood) would have effects on specific attentional components underlying the positivity effect. First, based on initial evidence from Demeyer and De Raedt (2013), we expected that induced mood changes would be related to faster disengagement from negative stimuli. Second, we also explored whether induced mood changes would be related to faster attentional engagement towards and slower attentional disengagement from positive

stimuli. However, based on the SAVI model (Charles, 2010), stress may hamper older adults to deploy this strength in attentional processing. Therefore, the current study served to clarify the direction of the influence of induced stress-mood state changes, as opposite to induced sad-mood state changes, in older adults' emotional attentional processes.

2. Method

2.1 Participants

Sixty older adults were recruited through recreation organisations for older adults. Based on a screening, 7 participants were excluded for scoring low on cognitive abilities (MMSE, see 2.2.1) and 3 participants were excluded for high BDI scores indicating the presence of depressive symptoms (see 2.2.2). Two participants did not complete the attention task due to problems in the detection of gaze position. Thus, analyses were performed on the 48 remaining participants (65 to 85 years old, *M*= 72.21, *SD*= 4.65).

2.2 Materials

2.2.1 Mini Mental State Examination (MMSE). This interview screened for cognitive impairments (Folstein, Folstein & McHugh, 1975). MMSE scores can range from 0 to 30, with higher scores indicating better cognitive functioning. Participants scoring 27 or above (O'Brient et al., 2008) were included in the study, leading to the exclusion of 7 participants.

2.2.2 The Beck Depression Inventory (BDI-II). The BDI-II (Beck, Steer, & Brown, 1996; Dutch translation: Van der Does, 2002), was used to investigate the presence/degree of depressive symptoms. Given the well-documented link between depression and negative attentional preferences (e.g. De Raedt & Koster, 2010), 3 participants scoring above 19, the standard cut-off indicating moderate depression (Beck et al., 1996), were excluded from analysis. In this sample, the scale demonstrated good internal consistency with a Cronbach's alpha of .86.

2.2.3 Visual Analogue Scale (VAS). VASs were used to assess current mood and consisted of four statements: 'How happy/sad/nervous/calm do you feel at this moment?'. Participants were asked to place a mark on a 100 mm line to indicate their level of agreement with each statement. This line was labelled on opposite ends: 'not at all' at the left and 'extremely' at the right. Participants' responses were scored by measuring the distance from the left of the line to the marked point with '0' being the lowest score and '100' being the highest score.

2.2.4 The stressor. We developed a new stressor procedure to increase feelings of nervousness and decrease feelings of calmness. Participants were presented with an unsolvable figure consisting of 9 squares. Each square was divided in 9 boxes (3 rows of 3 columns). In the first 8 squares, stars were randomly presented in one or multiple boxes. The last square was empty and participants were told that based on the first 8 squares, they would need to find a logical place for one or more stars in the 9th square. Participants were not aware of the fact that the complex figure had no correct solution. All participants were allowed to look at the task for 10 sec, a period in which they were told they should not give the solution but just study the problem. After the 10 sec period, participants in the stressor group were told that most people of their age were able to solve this within 5 minutes. Then, they were given 5 minutes to come up with a solution. Within that period, each time that they provided a solution they received feedback stating that they were wrong. In contrast, after the 10 sec period of studying the problem, participants in the control group were informed that they should not perform the task. This task was programmed using Inquisit software.

2.2.5 Engagement-disengagement task. The attention task developed by Sanchez and colleagues (2013*b*) was used to measure attentional deployment processes. Participants' eye movements were recorded with a Tobii tx-300 eye-tracker system. All participants were told they were performing a concentration task and were seated approximatly 65 cm from the screen.

Each trial started with a black screen (88.5 cm (width) x 50.5 cm (height)). After 500ms, a fixation cross was presented in the middle of the screen. Stimuli were pesented after the system detected a visual fixation on the central cross. Stimuli consisted of pairs of young to middle-aged faces: one neutral and one emotional expression (happy, angry or sad) of the same person. These pictures were selected from the Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998) based on a validation by Sanchez and Vazquez (2013). The validity of KDEF faces for older adults has been demonstrated (Demeyer & De Raedt, 2013). All pictures were fit in an oval window (size 19,5 (width) x 21 (height) cm) and non-relevant aspects (e.g. hair) were removed. These pictures were presented next to each other and were centered on the screen (39cm apart). Each pair (neutral-happy, neutral-sad or neutral-angry) was presented only one time and each time for 3000ms. During this period, participants were instructed to freely watch the screen without constraints. After the 3000ms free viewing period, there were 3 possible ways in which the trial could continue. In one third of the trials, a new cross appeared, indicating the start of a new trial (i.e., regular free-viewing condition). In another third of the trials, attentional *engagement* to emotional expressions was assessed. In this condition, after the 3000 ms period of naturalistic viewing, the task only continued when a visual fixation of 100ms on the neutral face was detected. This period is defined as a 'wait for fixation' period and lasted untill participants fixated on the neutral face. At that time, a white frame appeared surrounding the opposite emotional face. This frame could be a square or a circle and participants were instructed to quickly move their gaze towards the framed face and indicate the shape of the frame as quickly as possible (by pressing one of two response keys on the keyboard). Thus, this condition assessed the time to disengage attention from the neutral face in order to engage attention towards the emotional face. Following Sanchez et al (2013b) criteria, an attentional engagement index was calculated based on the averaged time that participants took to move their gaze towards the emotional face and make a fixation on it. Finally, another third of the

trials used a similar 'wait for fixation' procedure to measure disengagement from emotional faces. In this last condition, after the 3000 ms period of free viewing, the task only continued when visual fixation on the emotional face was detected. Then the frame appeared surrounding the opposite neutral face. These trials assessed the time to disengage attention from an emotional face and to engage attention towards a neutral face. An attentional disengagement index was calculated based on the average time it took participants to move their gaze away from the emotional face and make a fixation on the opposite face. Notably, the motor response was only used to motivate participants to redirect their gaze to the opposite face. Given that older adults are known for slower motor responses, gaze behavior is known as a more reliable measure in this sample (e.g. Isaacowitz et al, 2006).

Criteria to identify valid engagement/disengagement trials were: 1) fixation on the opposite stimulus before the frame appeared (i.e. detection of a valid fixation in the given stimulus during the 'wait for fixation' period), 2) saccades towards the framed face at least 100 ms after the frame appeared, 3) gaze was immediately directed to the stimulus surrounded by a frame (i.e., exclusion of trials with participants' gaze remaining at the initially fixated stimulus position or other positions on the screen for more than 1000 ms after the frame appeared), and 4) fixation of at least 100 ms to the stimulus surrounded by the frame after shifting their gaze to it. These criteria for discarding error and oultiers are based on Sanchez et al (2013b). An average of 89% (*SD*= 6%) trials per participants were identified as valid recordings. After this procedure of data cleaning, separate indices of attentional engagement and disengagement were computed for each emotional condition (hapy, angry, sad). The internal consistencies (Cronbach's α) of the engagement indices in our samples are .70 (happy), .65 (sad), .65 (angry). For the disengagement indices, they are .57 (happy), .65 (sad), .73 (angry).

There were 108 trials (36 neutral-happy, 36 neutral-sad and 36 neutral-angry pairs), which were preceded by 10 practice trials. An overview of trial sequence for all 3 types of trials

(i.e., control, engagement and disengagement conditions) is presented in Figure 1. The types of trials were randomly presented for each participant and were equally divided over the amount of neutral-happy, neutral-sad and neutral-angry pairs. Over the 3 types of pairs, both the square and the circle frame were equally likely to appear on the left or right side of the screen. Emotional faces were equally presented on the left as on the right side.

2.3 Procedure

This experiment was part of a larger older adult study[1], which was approved by the faculty's ethics committee. First, participants reported demographics (age, sex, marital status and education) and assessed their mood state on the VASs. Then, they were randomly assigned to the stressor or control condition. After this manipulation, participants completed again the VASs. The experiment continued with the engagement-disengagement task. Finally, the MMSE and the BDI-II were completed and participants were debriefed.

3. Results

3.1 Group Characteristics

Demographics for the stressor and control group can be found in Table 1. The two groups did not differ in age, $t(46)= .22$, $p = .83$, education, $\chi^2= 1.27$, $p = .53$, marital status, $\chi^2= 6.14$, $p = .19$, or gender[2], $\chi^2= 3.21$, $p = .07$.

3.2 Effects of the Manipulation on Mood States

The means and standard deviations of the VAS scores of both groups at pre- and post-manipulation measurements are shown in Table 2. To examine whether the manipulation was successful in inducing group differences in mood state, we performed a repeated measures MANOVA with the 4 mean VAS scores (happy, sad, nervous, calm) as multiple dependent variables, time (pre-, post-scores) as within subject variable and group (stressor, control) as between subjects variable. The analysis showed a main effect of time, $F(4, 42)= 3.24$, $p = .021$,

η^2_p = .24. Importantly, there was a significant Time x Group interaction, $F(4,42)$= 3.71, p = .011, η^2_p = .26, indicating differences between the groups on the VAS scores.

To further investigate these group differences, we performed separate 2 x 2 (Time x Group) ANOVAs for each VAS scale. For happy and sad VAS, we found significant main effects of time, $F(1,45)$= 5.19, p = .028, η^2_p= .10 and $F(1,46)$= 8.57, p = .005, η^2_p= .16, respectively. There was a general decrease in happy mood, $t(46)$= 2.16, p = .036, d = .32, and a general increase in sad mood, $t(47)$= 2.86, p = .006, d = .41. No significant effects were found for nervous VAS (all $F<$ .17, $p >$ .68), but a significant Time x Group interaction effect was found for calm VAS, $F(1,46)$= 13.49, p = .001, η^2_p= .23. Paired samples t-tests were used to investigate within-group changes in calm VAS over time. As expected, there was a significant decrease in calm mood in the stressor group, $t(21)$= 2.34, p = .029, d =.50. In contrast, the control group was characterized by a significant increase in calm mood across time, $t(25)$= 2.90, p = .008, d = .57.

3.3 Mood State Changes and Attention Processes

First, we tested between-group differences in attentional processes with 3 x 2 ANOVAs using group (stressor; control) as between subject, emotion (happy; angry; sad) as within subject and attentional engagement or disengagement indices as dependent variables. Given that engagement and disengagement are two separate processes (e.g. Posner & Cohen, 1984) that are measured with different types of trials, we used two separate ANOVAs. There was a marginally significant main effect of emotion for disengagement, $F(2,45)$= 2.97, p = .06, η^2_p= .12. However, there were no significant main or interaction effects with group for both attention indices (all $F<$ 1.40, $p >$ .26). Descriptive statistics for each attention index can be found in Table 3.

Second, based on the affective contrast theory (Manstead et al., 1983) which states that the influence of mood states depends on the contrast with preceding mood states, an individual

level approach was used to test the role of inter-individual mood state changes in subsequent attentional engagement or disengagement processes. Changes in mood were entered as continuous factors (covariates) in the analyses of effects in attention processes. First, we constructed residualized VAS change scores for each VAS that showed significant changes across time (i.e. happy, sad and calm) using simple linear regression in which post VAS scores were predicted by the corresponding pre VAS scores to reflect changes in mood (e.g., pre-happy VAS predicting post-happy VAS). Standardized residuals control for variability in baseline scores and are considered a reliable method to compute mood state change (e.g., Sanchez et al., 2013a, Segal et al., 2006). Second, to test for the influence of mood state changes on attentional process indices, mixed design ANCOVAs were conducted with emotion (happy, angry or sad stimuli) as within subject variable and residualized VASs change scores entered as covariates. ANCOVAs were conducted separately for each attention index (i.e., engagement and disengagement) and for the VAS mood change scores where inter-individual mood changes were found (happy, sad, and calm).

Analyses did not reveal significant main or interaction effects for attentional engagement (all $F < 1.16$, $p > .32$). For attentional disengagement indices, analyses showed a near significant Emotion x VAS sad mood change interaction effect, $F(2,45) = 2.55$, $p = .089$, $\eta^2_p = .10$, and an Emotion x VAS calm mood change interaction effect, $F(2,45) = 3.22$, $p = .05$, $\eta^2_p = .13$.

To further investigate these interaction effects, Pearson correlation coefficients between residualized VAS change scores in sad and calm mood and the 3 attentional disengagement measures (i.e., happy, angry and sad stimuli) were calculated. Notably, residualized change scores in calm mood and in sad mood only had a shared variance of less than 9 % ($r = .29$, $p = .049$). Residualized change scores in sad mood were significantly correlated with disengagement from happy stimuli, $r = .38$, $p = .008$, indicating that larger increases in sad

mood levels were related to longer time to disengage attention from happy faces. Moreover, there was a significant negative correlation between residualized change scores in calm mood and disengagement from sad stimuli, $r = -.29$, $p = .046$, indicating that larger decreases in calm mood levels were related to longer time to disengage attention from sad faces.

Given different levels of change in calm mood found between the stressor group and the control group, a moderation analysis was performed to investigate whether the associations between calm mood change scores and disengagement from sad stimuli reflect a general effect or whether they are specifically driven by the stressor. We conducted a moderation analysis (Hayes & Matthes, 2009) with residualized change scores in calm mood as predictor of disengagement from sad information, with group being entered as potential moderator. There were no main effects of group or calm mood change (all $\beta < -.25$, $t < 1.72$, $p > .09$). However, there was a significant Group x Calm mood change interaction effect, $\beta = -.45$, $t(44)= 2.38$, $p =.022$. The relationship between a decreased calm mood level and slower disengagement from sad faces was significant in the stressor group, $r = -.53$, $p = .012$, but not in the control group, $r = .08$, $p = .69$. Notably, similar moderation analysis with residualized change scores in sad mood as predictor of disengagement from positive information and group being entered as potential moderator only showed a main effect of sad mood change, $\beta = .39$, $t(44)= 2.81$, $p =.007$, but no effects (main or interaction) of group (all $\beta < .11$, $t < .52$, $p > .60$).

4. Discussion

In the present study, we aimed to clarify the conditions that may determine the occurrence of the positivity effect (i.e., attentional preference for positive stimuli compared to negative stimuli) in older adults' attentional deployment. We compared a group of older adults receiving a stressor to a control group to investigate whether this attentional preference would be more pronounced during negative/stressful conditions were emotion regulation would be needed. Furthermore, we employed an innovative attention task based on eye-tracking that

allowed direct estimations of attentional engagement and disengagement processes, in order to clarify specific attention components involved in the positivity effect. We found that increased sad mood across time was related to slower attentional disengagement from positive stimuli. In contrast, there were indications that decreased calm mood in the stressor group was related to slower attentional disengagement from negative stimuli.

Regarding to the effectiveness of the stressor, the groups showed a differential change trajectory in calm mood level. As expected, the stressor group decreased in calmness, whereas the control group showed an increase. Even though the manipulation did not significantly increase nervousness, these changes on the calm scale indicate that our manipulation was successful in inducing reactivity to a stressor. Given that the experience of task failure may be less arousing compared to more frequently used stress manipulations (e.g. speech tasks) and that older adults may be more reluctant to express negative mood (Charles et al., 2001), the nervousness scale might not have been sensitive enough to find changes. Furthermore, both groups showed happy mood decreases and sad mood increases across time. These effects might result from not being able to solve the complex figure in the stressor group, whereas similar mood changes in the control group might reflect disappointment about not getting the chance to solve the figure.

An individual level approach in the analyses of mood changes was used to investigate the link between increased need for emotion regulation (i.e., happy and calm mood decreases, sad mood increases) and the positivity effect in attentional deployment. Consistent with previous studies pointing towards mood-incongruent attentional preferences in older adults (e.g. Demeyer & De Raedt, 2013; Isaacowitz et al., 2008), increased sad mood in the whole sample was related to slower attentional disengagement from positive stimuli (i.e., happy faces). As previously argued (e.g. Isaacowitz & Blanchard-Fields, 2012), this indicates that older adults' attentional deployment does not merely reflect mood, but that it may serve emotion

regulation. Thus, this study replicates previous results on the link between sad mood increases and larger attentional patterns reflecting a positivity effect (e.g. Isaacowitz et al., 2008) and supports the notion of an increased use of this attentional emotion regulation strategy in older adults (Charles, 2010). Moreover, since there was no evidence of associations between mood change scores and attentional engagement, our data indicates that the specific component involved in this positivity effect seems to be related with processes of attentional disengagement rather than attentional engagement towards positive information. Specifically, our data suggest that older individuals experiencing increased levels of sad mood do not differ in shifting attention towards happy faces but that once this source of positive information is detected they invest longer times in the attentional processing of this information. Interestingly, research has shown that attentional disengagement processes rely on the activation of brain structures involved in the implementation of cognitive control (Sanchez, Vanderhasselt, Baeken & De Raedt, 2016). Therefore, our data suggest that larger times in disengaging attention from positive information might reflect older adults' intentional regulation of attentional patterns in order to modify their sad mood state.

In addition, our study indicates the need for research differentiating the positivity effect reported for sad mood state from attentional deployment effects resulting from increased reactivity to a stressor. Our preliminary results show that when calm mood decreases in response to a stressor, different attentional deployment patterns emerged: slower time to disengage attention from sad faces. This is indicative of mood-congruent attentional processing. Increased reactivity to a stressor may hamper the efficient attention strategies that regulate sad mood state. This finding is in line with the SAVI model (Charles, 2010) which highlights an age-related vulnerability in dealing with situations of high arousal, resulting in a prolonged recovery. In light of our results, detrimental attentional strategies increasing exposure to negative information might play a role in this difficulty to recover. Although this finding

requires replication, if confirmed by further research, it might be explained by the fact that stressors can put an emotional constraint on cognitive control. Optimal cognitive control may be a necessary requisite for the positivity effect in older adults to emerge (e.g. Knight et al., 2007). A recent meta-analysis by Reed and colleagues (2014) confirms that the positivity effect is larger when there are no cognitive constraints. Therefore, reactivity to a stressor (decreased calmness) may result in impairments in the ability to disengage attention from negative information. Interestingly, this finding is also in line with the idea that increased vulnerability towards stressors is related to difficulties in disengaging attention from negative information (for a review, see De Raedt & Koster, 2010).

Contrasting with results from the individual level approach, no general between-group differences in attentional processes were observed. This might be due to the large inter-individual differences in mood generated by the stressor. Future research is necessary to clarify the effects of distinct negative mood states (i.e., sadness, stress reactivity) on attentional deployment in older adults. Moreover, given the novelty of our findings, further research is needed to investigate the effectiveness of the attentional deployment strategy in recovering from the distinct negative mood states. To confirm that the positivity effect in older adults' attention reflects an efficient emotion regulation strategy after experiencing increases in sad mood, a post-measurement of emotional state after completing the attention task might help to determine whether negative mood improves by using this type of attentional deployment. In line with this idea, Sanchez et al (2013a) tested a sample of undergraduates who underwent a sad mood induction and then completed an eye-tracking task measuring sustained attention towards happy faces. Consistently with our results, individuals experiencing higher increases of sad mood as result of the mood induction procedure showed more sustained attention towards happy faces in the following attention task. Moreover, these larger positivity effects in attention were predictive of subsequent larger decreases of the induced sad mood after completing the attention

task. Whether in older adults, characterized by a larger positivity effect as compared to younger adults (e.g., Reed et al., 2014; Scheibe & Carstensen, 2010), these attention patterns would also relate to more benefits in subsequent regulation of negative mood will require further research. If, in contrast, reactivity to stressors is hampering efficient emotion regulation through the positivity effect, it is possible that older adults use other types of emotion regulation strategies during stress. Further research would benefit from evaluating a broader set of emotional strategies in response to stress reactivity in order to clarify these differential effects.

Of note, we also investigated attentional deployment patterns in the processing of two distinct types of negative stimuli: sad and angry faces. As mentioned above, we only found effects in attentional processing of sad faces, but not for angry faces. One possible explanation is that the relevance of different negative information sources may depend on the task environment. Whereas previous studies have used external material (e.g. film clips) to induce negative emotions, we used a stressor that might have made sad stimuli more salient/relevant, as they might elicit feelings of failure. From a discrete emotions perspective, the experience of sadness and anger develops differently over the course of life (Kunzmann, Kappes, & Wrosh, 2014). While there is an age-related reduction in anger reactivity, sadness becomes more salient in older adults. Since older adults show greater responses to sad stimuli (Seider, Shiota, Whalen, & Levenson, 2010), the positivity effect may be more needed during the confrontation with sad stimuli.

Besides the partial effectiveness of our stressor (changes in calm, but not in nervous mood), some other limitations have to be considered. First, a younger comparison group was not included in our study. Recently, Reed & Carstensen (2012) have postulated that even a preference for negative stimuli in older adults can be seen as a positivity effect when a younger comparison groups shows an even larger negative preference. In future research it could be investigated whether the effects found in our study are unique to older adult populations.

Nonetheless, we set out to identify within-group differences determining the occurrence of the positivity effect and our results indicate that this effect may be efficient for older adults during sad mood, but not during stress mood. Second, we relied on self-report measures to investigate the effects of the stressor. Future research might benefit from using psychophysiological indicators (e.g., heart rate, skin conductance) to get an objective rate of stress level change. Third, the difference in task length between groups may have led to changes in unrelated processes such as fatigue. However, our main results are based on an individual level approach and not on between-group differences. Finally, even though the internal consistency of this task is good, it is relatively lower than what is found using this task in younger samples (e.g. Sanchez et al., 2016), which might result from a greater loss of trials due to vision problems in older adults. Therefore, future research might need to include more trials when investigating engagement and disengagement in older adults. Yet, internal consistency scores in the study were satisfactory for an experimental design and are higher than those typically reported in studies using reaction time-based measures of attention (e.g., Kappenman, Farrens, Luck, & Proudfit, 2014). Moreover, the eye-tracking design helps to overcome problems with age-related motoric slowing. Therefore, an improved version of this paradigm may be the most suitable method to index visual attention processes in older adults.

Notwithstanding these limitations, this is, to our knowledge, the first study to confront older adults with a stressor to evaluate its effect on attentional processing of emotional stimuli. Moreover, the present study extends previous findings by using an innovative task that allowed disentangling the specific attention components of emotional processing involved in the positivity effect of older adults. Specifically, our findings support the idea that the positivity effect emerges in later components of attentional maintenance, namely delayed disengagement from positive information, which may reflect intentional attentional deployment to regulate sad mood (Sanchez et al., 2013a). However, our results also indicate that a stressor may put a

constraint on the use of this strategy, as reduced calm mood is related to difficulties in disengaging attention from negative information. Further research into the effects of stress on the positivity effect in older adults is needed. Given these findings, further research into the effect of distinct negative mood states might contribute to understanding the conditions in which the positivity effect in older adults occurs.

Acknowledgements

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Footnotes

[1] The data for this study were gathered in a larger experiment with older adults. Participants also completed measures on self-esteem and expectations. Then they had a break before completing the current procedure. Afterwards, they also completed personality measures.

[2] Given the marginally significant gender differences between the stress induction and control group, we investigated whether adding gender as a between subjects factor in the 3(emotion) x 2(group) ANOVA's with the 2 attention indices as dependent variables might influence results. There were no significant main or interaction effect with gender for both attentional engagement and attentional disengagement (all $F < 1.15$, $p > .33$).
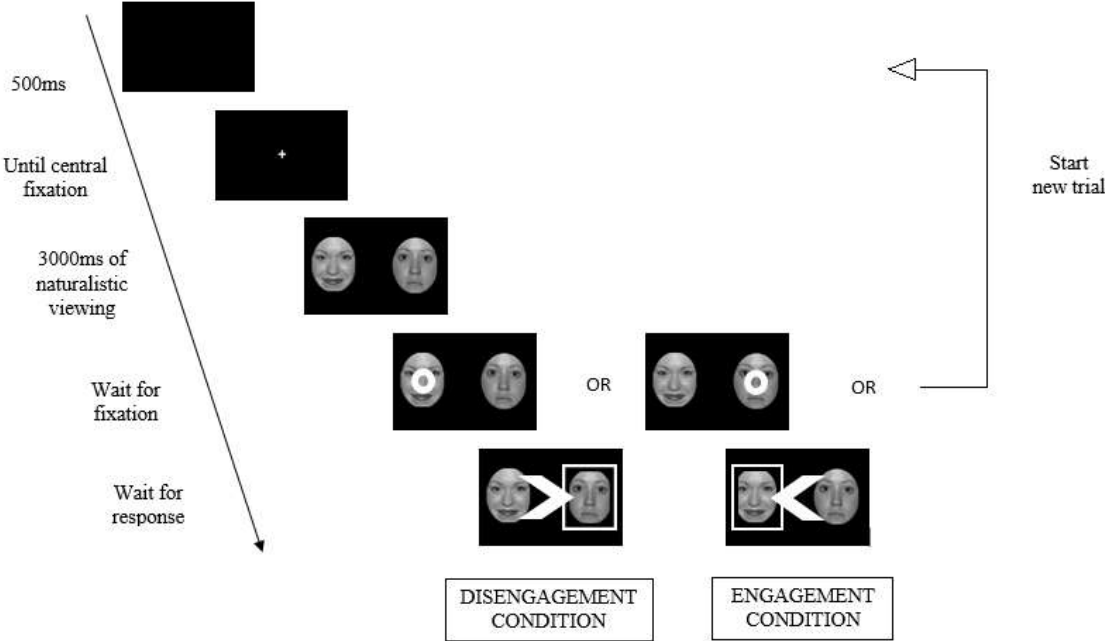
Figure 1. Trial sequence for engagement and disengagement trials in the attention task.

Table 1 .

Demographic characteristics of the tension induction and control group.

variable	Stressor group	Control group
N	22	26
male/female	7/15	15/11
mean age *(SD)*	72.05(4.10)	72.35 (5.15)
Marital status (in %):		
married/living together	68.2	61.5
single/divorced	22.7	23.1
widow(er)	9.1	15.4
education (in %):		
no diploma	18.2	7.7
high school	40.9	42.3
higher education	40.9	50

Table 2.

Means and standard deviations of the VAS scores in the tension induction and control group at pre and post measurement.

	Stressor group				Control group			
	pre		post		pre		post	
VAS	M	SD	M	SD	M	SD	M	SD
Happy (0-100)	59.77	20.72	46.41	26.89	56.96	28.65	54.28	32.08
Sad (0-100)	9.50	16.93	21.95	26.92	9.92	15.50	16.31	20.48
Nervous (0-100)	19.45	30.27	21.09	22.37	17.27	22.50	15.42	17.02
Calm (0-100)	72.45	30.33	51.27	31.16	41.38	34.32	60.58	31.77

Table 3.

Means and standard deviations of each attention index in the total sample and in the tension induction and control group.

Attentional index	Total sample M(SD)	Stressor group M(SD)	Control group M(SD)
Engagement			
Happy faces (ms)	308 (08)	297(06)	318 (09)
Angry faces (ms)	314 (11)	292 (05)	333 (14)
Sad faces (ms)	308 (07)	293 (05)	320 (08)
Disengagement			
Happy faces (ms)	317 (10)	314 (11)	318 (09)
Angry faces (ms)	285 (05)	284 (05)	285 (05)
Sad faces (ms)	292 (05)	303 (05)	282 (04)

Note. Engagement is the averaged time participants took to direct their gaze towards the emotional face and make a fixation on it. Disengagement is the averaged time participants took to direct their gaze away from the emotional face and make a fixation on the neutral face.