

Emotional Working Memory in Ageing and Anxiety

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ABSTRACT

Altered processing of emotional information in ageing or anxiety can be indicative of a disruption of one's well-being. A total of 97 participants were tested with a novel delayed match-to-sample task consisting of positive and negative facial expressions with different levels of emotional intensity. Results show a decrease in the working memory accuracy for the recall of negative stimuli in high relative to the low trait anxiety group, while older adults showed a bias to recall negative faces as less negative compared to their younger counterparts. The relationship between emotional working memory and anxiety was not influenced by age. Anxiety and age modulate emotional working memory in different ways; interestingly, the results suggest separable effects on processing of negative stimuli in working memory.

Keywords

Working memory, anxiety, ageing, emotion, match-to-sample.

INTRODUCTION

Affective disorders are considered to be among the most prevalent mental health problems in modern society¹. One-year prevalence was estimated between 6.0% and 6.8% for any anxiety disorder worldwide². This prevalence tends to decline with age but is still a pressing issue in older adults³. Typically, anxiety disorders are characterized by emotional dysregulation and functional difficulties¹. Quality of life is found to be severely impacted in high anxious younger adults and older adults with a diagnosed anxiety disorder or with symptoms related to anxiety⁴. Interactions between anxiety and age suggest greater experienced disability in older adults with high levels of anxiety compared to highly anxious young adults⁵. Considering the widespread impact of anxiety disorders on human well-being across the lifespan, a deeper understanding of the underlying aetiology is necessary in order to increase the efficacy of current treatments.

Typically, studies find that older adults – compared to young adults – exhibit a similar or more elaborated processing of positive information and a less exaggerated response to negative stimuli^{e.g.}⁶. Conversely, anxious individuals have been shown to be more sensitive to negative information than positive information. This facilitation manifests primarily at early perceptual

processing stages (<500 ms), whereas presenting anxious individuals with emotional images for a longer duration can lead to a decrement in behavioural performance⁷. This avoidance response is argued to interfere with habituation of the fear response. The current study will examine the elaborate processing of emotional information by studying working memory (WM) performance for positive and negative information. WM is a key system in monitoring attention and perception which serves to complete complex cognitive tasks by temporarily storing and manipulating information⁸. Altered processing of emotional expressions can have detrimental effects on social functioning, causing interpersonal conflicts that consequently reinforce anxiety symptoms⁹. Therefore, it is highly relevant to explore processes that impair normal cognitive functioning.

To study recall for emotional stimuli we used a novel experimental paradigm, designed to be sensitive to accuracy and potential biases for emotional stimuli in ageing and anxiety. For the current study, we hypothesised that: (1) anxiety decreases accuracy for negative information and therefore high trait anxious participants perform worse for fearful faces in the WM condition; (2) older adults are more accurate in their responses to happy faces relative to fearful faces in the WM condition; and (3) anxiety interacts with ageing in that younger adults are by default more attentive to negative information than older adults, resulting in a stronger effect of anxiety on performance of older adults.

By using a match-to-sample task in which subjects adjusted the probe stimulus to the memory of the target stimulus we aimed to measure the quality of the WM representation for emotional material. In addition to the WM task, participants also performed a perceptual-matching condition to control for non-memory dependent emotional biases. Moreover, control conditions using non-emotional stimuli for both working memory and perception were conducted.

Previous studies described high trait anxious subjects performing worse on tasks with prolonged attention for a fearful face⁷, therefore we expect the high trait anxiety subjects would have lower accuracy for fearful faces, especially for low and moderate emotional intensities. Highest levels of anxiety are suggested to be highly salient for all participants, equally so for high trait anxiety subjects. Considering the positivity effect in ageing can benefit task performance with positive stimuli, ageing was predicted to enhance the processing of happy faces compared to fearful faces. We predict that the relationship

of emotional processing with anxiety traits differs over age, adversely affecting older anxious adults⁵.

METHODS

Participants

Fifty-three young (18-35 years old) and forty-four elderly (60-81 years old) participants were recruited for the current study. Due to technical issues, data of three older adults and one younger adult was excluded from analyses. Participants were divided into subgroups of high and low trait anxious. In the current study we used a STAI score of 40 or higher as a cut-off point for the high-trait anxiety group.

Procedure

Prior to the behavioural task, subjects completed the State-Trait Anxiety Inventory (STAI)¹⁰. The computer-based task consisted of 4 task conditions and 300 trials in total – excluding the test trials. The entire session took approximately 2 hours to complete.

Task

Each trial started with a GO-screen on which participants clicked to initiate the trial. In the emotional face WM condition participants were presented with a happy or fearful face for 500 ms directly followed by a 100 ms mask and 3000 ms retention interval (figure 1).

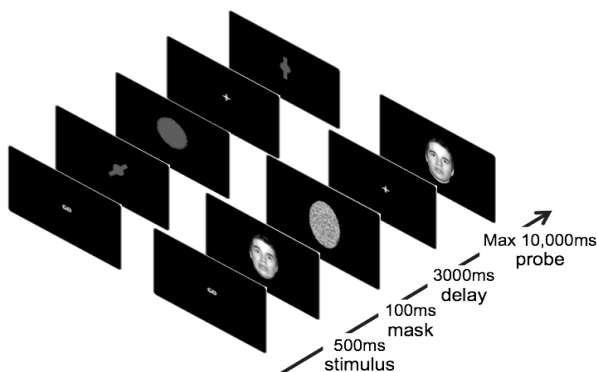


Figure 1: WM conditions task design. Task schematic for the visual and emotional delayed-adjustment task

After the delay, participants were asked to adjust the expression of the face-probe to match the target stimulus as accurately as possible in order to test their memory for the emotional face. The participant scrolled a track ball mouse to adjust the emotional intensity of the probe until it matched the remembered expression on the previous display. In separate blocks participants completed the emotional perceptual condition. Here, two faces with the same identity were simultaneously presented on the left and right sides of the screen. Participants matched the two faces on screen as accurately as possible by adjusting the expression using the track ball mouse. The visual - non-emotional - WM condition was included to assess participants' WM abilities for non-emotional items. In this condition, randomly oriented bar stimuli were used as targets. Participants were asked to recall the orientation of the bar after the 3-second delay (figure 1).

The visual perceptual condition included two oriented bar stimuli. Participants were asked to adjust the orientation of the right shape to match the randomly drawn orientation of the left shape by rotating the mouse track ball.

Stimuli

The face stimuli for the emotion tasks were obtained from the NimStim face stimulus set (<http://www.macbrain.org/resources.htm>). With Morpheus Photo Morpher (<http://www.morpheussoftware.net/>) emotional expressions ranging from 0% to 100% were created by increasing emotional intensity in steps of 1%. The 10 best quality morphs were used in the experiment, and a set of 6 other identities were used for the practice trials. In the emotional WM and the emotional perception condition, emotional expressions of 20 different intensities were used varying by 5%, excluding 50% to keep an even number of conditions. For the visual condition, blue orientation stimuli (line bars with a circular disk in its centre) were used. The orientations were randomly generated for each participant.

Analyses

For all conditions, the difference between the target stimulus and probe response was used as measure of performance. By adapting the precision working memory task used in visual psychophysical experiments¹¹, we were able to test for sensitivity to emotional information in WM, shifts in ability to remember emotional expressions, and modulations of the intensity of emotional expressions remembered.

To determine bias, error, and accuracy specific for emotional WM, all other task conditions (i.e. non-emotional conditions and non-memory conditions) were administered to isolate effects of emotional WM. Bias is defined as the mean of the error distribution, calculated by subtracting the target value from the response value for every trial. Mean error was calculated by the mean of the absolute values of the error distribution. Furthermore, we also looked at accuracy – defined as the inverse of the standard deviation (SD^{-1}), suggested to be a sensitive measure of the quality of the memory representation¹². In order to co-vary out perceptual effects, residuals were obtained for every subject from a partial regression with emotional perception score as covariate.

RESULTS

Visual perception & working memory conditions

A non-parametric Wilcoxon rank sum test showed old and young participants differed in their performance on the visual perception condition ($Z_{95} = 2.156, p = .031$) but not on the visual working memory condition ($p = .348$). No differences were found when high and low trait anxiety groups were compared on their ability to match bar shapes in the perceptual condition ($p = .471$) or recall the bar shapes ($p = .198$).

Emotional perception condition

To compare mean error with both anxiety and age groups as between-group variables, a two-way analysis of variance (ANOVA) was computed. For error in fearful faces, there was an effect of age ($F_{1,93} = 12.35, p = .001$)

but no effect of anxiety ($p = .675$) or interaction between age and anxiety ($p = .507$). Age did not influence judgement about the emotional valence of fearful expressions ($p = .057$), nor did anxiety ($p = .709$). Analysing mean error of happy expressions, no significant effects of age ($p = .212$), anxiety ($p = .176$) or group interactions ($p = .357$) were observed. Furthermore, no systematic biases were observed when matching happy faces.

Emotional working memory condition

Comparing anxious and non-anxious individuals did not show a difference in accuracy or mean error for fearful faces between the groups (accuracy $p = .101$; mean error: $p = .186$). However, after controlling for accuracy in the perceptual condition, anxious participants in fact showed lower accuracy for fearful faces ($t_{95} = 2.453$, $p = .016$) and a trend for mean error scores was observed ($p = .063$).

Testing for relative performance for emotional (i.e. positive and negative) target faces in anxiety, a mixed ANOVA was performed (figure 2). This revealed a significant effect of emotion ($F_{1,95} = 40.01$, $p < .001$) and a significant interaction between emotion and anxiety-group ($F_{1,95} = 7.381$, $p = .008$) (see figure 2a). After co-varying out performance on the perceptual condition to correct for the ability to match emotional faces for each emotion separately, the significant interaction between emotion and anxiety remained ($F_{1,96} = 6.300$, $p = .014$). No such effects were found for positive expressions or between age groups.

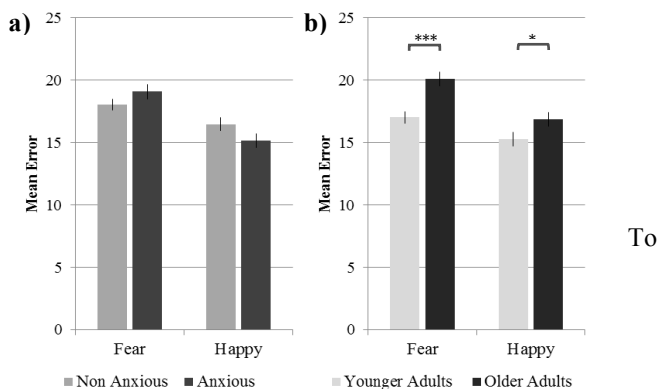


Figure 2: Error scores on emotional WM task. A) Performance displayed for anxiety groups and B) age groups. Analyses showed interactions of anxiety and age with emotion (i.e. happy and fear). Depicted standard error bars. * $p < .05$; ** $p < .01$; *** $p < .001$.

further investigate how age affected emotional processing, the bias for both emotion conditions were analysed using a mixed ANOVA. Older adults underestimated fearful emotions and performed the same on trials with positive target faces ($F_{1,95} = 6.047$, $p = .016$). Interestingly, after correcting this bias for perceptual abilities, there was a significant interaction between emotion of target stimulus and age ($F_{1,95} = 4.170$, $p = .044$). Thus, there was a bias to underestimate fearful faces in older adults, at least partly driven by WM.

To test the hypothesis that older adults are more affected by anxiety than younger adults in emotional working memory, a 2×2 mixed design ANOVA was conducted for

anxiety-group \times age-group for happy and fearful emotions separately, corrected for perceptual performance. Even though anxiety had an effect on accuracy for fearful faces ($F_{1,93} = 4.982$, $p = .028$) and ageing on bias for fearful faces ($F_{1,93} = 4.514$, $p = .036$), there were no significant interactions between age and anxiety observed for either accuracy (fearful faces: $p = .373$; happy faces: $p = .367$), or bias (fearful faces: $p = .770$; happy faces: $p = .549$).

Emotional intensities

An effect of emotional intensity was seen for positive emotional expressions (figure 3; $F_{9,93} = 7.491$, $p < .001$), and no intensity \times age \times anxiety group interaction was observed ($p = .099$). No effect of emotional intensity on error scores was found for fearful faces ($p = .088$) and no interaction was observed either ($p = .897$). In addition, to observe whether there was an age-mediated difference between emotional WM and perception conditions in high versus low anxious participants for a bias matching fearful faces a ($10 \times 2 \times 2 \times 2$) mixed design ANOVA implied a near significant interaction ($p = .069$).

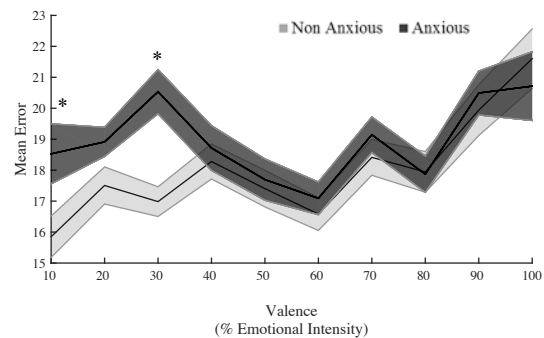


Figure 3: WM error for negative faces as a function of emotional intensity. The low and high trait anxiety groups differ (grey and black line respectively) in their error scores for low and not high emotional negative faces. Depicted standard error bars. * $p < .05$

DISCUSSION

The present study investigated processing biases for ageing and anxiety in a novel emotional WM task. Evidence was found for a negativity effect in anxiety, showing lower accuracy for fearful faces in high trait anxious participants relative to the low trait anxiety group. Furthermore, it was reported that older adults showed a bias to underestimate fearful emotions. Both findings were most pronounced in stimuli ranging from low to moderate emotional intensities. Main interactions for these measures between age and anxiety were absent. After controlling for perceptual performance (not reliant on memory), it was shown that both the negativity effect and a positivity bias in elderly were at least partially WM-dependent.

These findings support the notion that WM processing of negative stimuli performance for anxious participants is impaired^{7,13}. Moreover, the present study also supports evidence that avoidance of fearful stimuli in anxiety is largest in low levels of threat¹⁴. Furthermore, results only partially support the research showing superior recall for

positive compared to negative information^{15, 16}. Earlier studies showed that older adults performed better on positive compared to negative stimuli relative to younger adults^{6, 17}. Here, a positivity bias was found for negative but not positive faces (i.e. biased performance for negative stimuli). This bias extends the findings of Svård et al.¹⁸, who also studied delayed recall for positive and negative faces of varying emotional intensities. Unlike Svård et al.¹⁸, who showed a bias to undervalue all emotional expressions, the current study examined a bias specific for negative information. The longer delay period used in the present study could enlarge relative differences in responses to positive and negative faces. While both the effects of ageing and anxiety interfere with emotional processing of negative stimuli we did not find the interaction previously reported by Brenes et al.⁵. Current findings suggest effects of ageing and anxiety on emotional working memory are separable. In line with the results of Brenes et al.⁵ we speculate that the negativity effect might cause greater disability in older adults performing daily activities as a result of factors not taken into account in the present study.

Conclusion

In summary, results of this study revealed a negativity effect in anxious participants showing lower sensitivity for negative stimuli in working memory. We also showed that older adults exhibited a positive bias / reduced negative bias in their responses to negative faces compared to positive faces relative to younger adults. This supports earlier studies showing evidence of maladaptive processing of negative stimuli in anxiety and also supports results of earlier studies examining a positivity bias in older adults, albeit only for negative stimuli. In conclusion, the present findings showed a negativity effect of anxiety and a positivity effect of ageing in emotional working memory and also found that these effects did not significantly interact with each other.

ROLE OF THE STUDENT

Jasper Hajonides van der Meulen was an undergraduate student collaborating with DPhil-student Robert Mok. The collection of the data, the analysis of the results as well formulation of the conclusions and the writing were done by the student.

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