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Research article

Role of stimulus types and valence on the affective memory performance of adults with anxiety

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HIGHLIGHTS

- The positivity inhibition effect was present for words but not pictures.
- Positive words caused more sensitivity when evaluating as per health status.
- Differences in affective working memory performance are present in anxiety disorders.

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ABSTRACT

Previous studies have found that the emotion of anxiety in adults is easily influence by negative stimuli However, few studies have explored the effect of stimulus types on working memory performance and cognitive processing of adults with anxiety. This study aimed to explore the effects of anxiety on affective working memory and the role of stimulus types and valences on affective working memory performance. Forty adults were recruited for the experiment and were divided into two groups according to their anxiety levels. The valence and type of stimulus were manipulated in a memory recognition experiment. The results indicated that individuals with anxiety performed poorer when subjected to positive stimuli than for neutral and negative stimuli, whereas healthy adults exhibited the opposite. Furthermore, participants outperformed on affective pictures than affective words, but the effect size of the words was larger than that of the pictures for the difference between the valence and anxiety groups. This study highlights the differences in affective working performance across stimulus types and valences between healthy adults and adults with anxiety. The findings clarified the effect of positive valence and affective words on the affective working memory processing mechanism in adults with anxiety.

1. Introduction

An affective stimulus is an object or event that arouses an individual's emotion. The valence of the stimulus can be positive, neutral, or negative (Strapparava et al., 2006). Affective working memory is defined as that fundamental mechanism of the mind which involves integrating specific cognitive and affective processes and it being actively maintained and worked with feeling states (Mikels and Reuter-Lorenz, 2019). Atkins and Reuter-Lorenz (2008) conducted the recognition and recall tasks using emotional stimuli to explore the emotional regulation in working memory. Their results demonstrated that feeling maintenance is influenced by the emotional stimuli, meaning that people have an online maintenance subsystem of affective memoranda. They also found different maintenance performance tendencies between positive and negative valence. Mikels et al. (2008) manipulated affective and cognitive mechanisms in the delayed-response task and selective interference task to investigate the maintenance of affective working memory. Their results revealed that the performance of affective mechanisms were influenced by affective reconciliation, indicating a specific domain in working memory for affective processing. In a study by Pan et al. (2022), working memory and emotional working memory training task were conducted to study implicit and explicit emotional regulation in working memory. Their results demonstrated that working memory training without emotional stimuli could enhance explicit emotional regulation but that training with emotional add-in improve the implicit emotional control in working memory mechanism. Thus, affective materials can modulate

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working memory, and working memory performance can be influenced by their valence and strength (Mikels and Reuter-Lorenz, 2019).

Knott et al. (2018) used the Deese/Roediger-McDermott (DRM) paradigm and DRM words list to investigate the effect of valence on working memory and found that participants performed with lower accuracy on negative words compared to positive and neutral words. This indicated that positive and neutral words could make up controlled processing. Piguet et al. (2008) used affective words, which were selected from the Affective Norms for English Words database (ANEW; Bradley and Lang, 1999), to investigate differences in valence processing between younger and older adults. They found that older adults had a higher false alarm rate for positive word recognition, indicating that they made more mistakes in positive stimuli, whereas younger adults performed better for negative words than for positive and neutral words. They proposed that the positive valence can significantly trigger similar memories and disrupt memory in older adults, and that the efficiency of emotional memory processing and control decreases with age. From the neuropsychological perspective, Smith et al. (2018) used emotional pictures in affective working memory maintenance tasks to investigate the emotional feeling maintenance and found a unique association between emotional feeling maintenance and medial prefrontal cortex region activation. This means that emotional feeling maintenance is connected to the top-down control of emotion (Smith and Lane, 2015).

Anxiety is another factor that can influence emotional memory performance, and people with anxiety have a lower working memory capacity (Moran, 2016). Fales et al. (2010) found that a significant interaction between emotional valence and the anxiety level affected working memory performance. In their study, participants with a high level of anxiety exhibited greater brain activation when they memorized negative faces. They also proposed that the valence and anxiety level would determine whether emotional stimuli would enhance or interfere with the memory processing mechanism. A study by Romano et al. (2020) found that socially anxious participants displayed a positivity deficit in memory performance, which indicates that the valence of the stimuli influences their memory processing. Engen and Anderson (2018) proposed that people could successfully regulate emotional impact by modulating amygdala activity in brain, but that patients with affective psychopathologies exhibit emotional memory control impairment. In other words, working memory is associated with emotional processing deficit. Mikels et al. (2008) also thought that there is an affective subsystem within the working memory system and that this subsystem is related to the orbital frontal cortex and amygdala regions. Schweizer et al. (2019) reviewed 165 affective information and working memory studies to explore the affective effect on working memory capacity and found that working memory performance varied by the valence of stimuli and tasks. Furthermore, their results exhibited that patients with mental health problems performed with lower accuracy on emotional stimuli compared to healthy adults, and also deduced that the working memory was associated with ventrolateral prefrontal cortex, the amygdala, and the temporo-occipital cortex at the neural level.

The previous literature (Atkins and Reuter-Lorenz, 2008; Mikels and Reuter-Lorenz, 2019; Mikels et al., 2008) reveal that affective working memory is maintained and functions on the basis of feeling and that recognition forms the paradigm that helps measure participants' sense of familiarity of information. Furthermore, Miura and Itoh (2016) proposed that recognition tasks could be used to explore the revelation effect caused by eliciting the feeling of resolution rather than a visual search. To understand the effect of valence on the maintenance and recoding of feelings in the group of patients with anxiety, the recognition task was conducted. Furthermore, the recognition task is generally considered to be less stressful and anxiety-provoking than many other memory tasks.

In addition, affective valence and mental health play an important role in the affective working memory system. Previous studies (Atkins and Reuter-Lorenz, 2008; Frühholz et al., 2016; Piguet et al., 2008) usually used single perceptual stimuli types to explore the effect of affective valence on working memory rather than investigating the differences across multiple perceptual types and interactions between the valences and stimuli types. Individuals with anxiety could not modulate affective reflection, which also influenced their affective working memory (Romano et al., 2020). Whether the different stimulus types and valences would cause difference on performance of affective working memory between healthy adults and adults with anxiety was our main question. Our findings clarified how the affective stimuli attribute influences the affective working memory mechanism in the anxiety group. The current study attempted to increase the knowledge of relationship between valence and stimuli types in individuals with and without anxiety. In addition, we focused our analysis on the cognitive-behavior performance of anxiety group to understand their impairment on affective stimulation specifically in positive valence.

2. Methods

The experimental design and procedure of this study were approved by the Institutional Review Board of Changhua Christian Hospital.

2.1. Participants

As can be seen in Table 1, a total of 40 participants were included in the current study. They were divided into two groups according to their health status: healthy adults and adults with anxiety. Based on the heuristic described in past literature (Moon and Jeong, 2015; Moreno et al., 2015; Morey et al., 2011), we recruited 20 participants for each group. The anxiety groups were those with anxiety disorders that had been diagnosed by their physician and who had a State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) score over 40. Healthy adults were recruited from local community centers and adults with anxiety were recruited from local hospitals. The STAI scores of the healthy adults were below 40. There were no significant differences in age between the two groups ($p = 0.784$), wherein $M = 46.00$ ($SD = 17.74$) for the healthy group, and $M = 44.55$ ($SD = 15.44$) for the anxiety group. Individuals with obvious speech problems and severe disabilities in basic daily functioning, and those who could not comprehend the instruction and respond to stimuli were excluded.

2.2. Apparatus and stimuli

The STAI was used to evaluate the anxiety level of the participants. The emotional stimuli were derived from the IAPS (Lang et al., 1998) and ANEW databases. The valence levels of the positive, negative, and neutral stimuli were significantly different ($p < 0.05$) and their arousal level was between 3 and 5. The materials of this study were presented randomly so that each participant experienced different orders of stimuli to reach the material counterbalance. All stimuli were presented on a 15.6 inch laptop screen, and E-prime 2.0 (Psychology Software Tools, Sharpsburg, PA, USA) was used to create the experimental procedure and collect data throughout the experiment.

2.3. Procedure

Participants were informed of the purpose of the research and were requested to provide informed consent. To ensure that the participants understood the procedure, a practice trial was performed prior to the

Table 1. The age and State-Trait Anxiety Inventory scores of the two groups of participants.

Group	*N*	STAI (*SD*)	
		State (*SD*)	Trait (*SD*)
Healthy adults	20	33.05 (4.81)	34.55 (5.16)
Adults with anxiety	20	55.75 (6.67)	58.85 (6.93)

SD = standard deviation; STAI = State-Trait Anxiety Inventory.

formal trials. In the practice trial, three emotional pictures or words were presented to the participants and they were asked to memorize them during a memory phase. Six emotional stimuli were then presented during a recognition phase.

The formal trials involved two phases, namely the study phase and test phase (Figure 1). First, instructions that informed the participants about what would happen and how they should respond during the experiment were presented on the screen. Next, a fixation cross was presented for 5,000 ms to gain the participants' attention. Then, thirty emotional pictures or words were presented randomly for 2,000 ms, and after each emotional stimulus, a blank slide was presented for 2,000 ms. The participants were asked to memorize the stimuli during the study phase. After the study phase, participants rested for 5 min and entered the test phase. During the 5 min, participants did nothing but sit on their chair alone. In the test phase, 60 emotional pictures or words (30 old and 30 new) were presented randomly for 2,000 ms, and a blank slide was presented for 2,000 ms after each emotional stimulus. The participants were asked to indicate whether each stimulus was new or old, and they responded by pressing "A" for old and "L" for new on the keyboard. Each participant was presented with 60 trials in the experiment. The accuracy was recorded during the experiment.

2.4. Statistical analyses

IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA) was used for the statistical analyses. Analysis of variance (ANOVA) and the post-hoc test were used to examine the effects on the factors. The correlation coefficients were used to understand the relationship between affective memory and the severity of anxiety. To identify the possibility of discrimination between groups by using affective memory performance, a discriminant analysis was conducted. The significance level was .05 for all the analyses.

3. Results

3.1. Affective memory performance

The ANOVA also revealed that the stimulus type × valence × health status interaction was significant, wherein $F\ (2, 76) = 4.316$, $p = 0.017$, $\eta^2_p = 0.102$. As can be seen in Figure 2, the participants demonstrated a higher level of accuracy when the stimulus was a picture ($M = 0.91$, $SD = 0.09$), which indicates that the affective pictures were easier to memorize than the affective words ($M = 0.827$, $SD = 0.11$). Additionally, there was a significant difference between the two types of health status for both the positive pictures, wherein $t\ (38) = 4.676$, $p < 0.001$, d $= 0.896$, and for positive words, $t\ (38) = 2.833$, $p = 0.008$, d $= 1.479$; healthy participants outperformed those with anxiety. Regarding the performance of the healthy participants, they correctly recognized the positive stimuli more than the neutral and negative stimuli for both pictures (neutral: $t\ (19) = 2.734$, $p = 0.013$, d $= 0.690$; negative: $t\ (19) = 2.669$, $p = 0.015$, d $= 0.481$) and words (neutral: $t\ (19) = 3.676$, $p = 0.002$, d $= 0.981$; negative: $t\ (19) = 2.33$, $p = 0.031$, d $= 0.503$). Interestingly, for the words, participants with anxiety correctly recognized the negative stimuli more than the neutral and positive stimuli (neutral: $t\ (19) = 3.298$, $p = 0.004$, d $= 0.906$; positive: $t\ (19) = 5.223$, $p < 0.001$, d $= 1.287$). For the pictures, they also exhibited better recognition of the negative pictures than the neutral pictures, wherein $t\ (19) = 3.488$, $p = 0.002$, d $= 0.701$, but there was no difference between the negative and positive pictures, wherein $t\ (19) = 1.902$, $p = 0.072$, d $= 0.451$.

3.2. Correlation between affective memory performance and state-trait anxiety inventory scores

To explore the relationship between the affective memory performance and the severity of anxiety, this study conducted the Pearson correlation coefficients of affective memory performance and State-Trait Anxiety Inventory Scores. As shown in Table 2, there was a negative relation between positive word memory performance and state ($r = -0.515$, $p = 0.001$) and trait ($r = -0.545$, $p < 0.001$). This meant that with an increase in the severity of their anxiety, participants performed poorer on positive memory of words.

3.3. Discriminant analysis

We conducted a discriminant analysis to determine whether different stimulus types and valences could be used to classify participants as healthy or with anxiety on their affective memory performance. Furthermore, the correlation results reveal that the severity of anxiety demonstrated a relationship with positive words, which meant that affective stimulus may be a key factor in classifying participants. In clinical criteria, participants can be defined as healthy adults or adults with anxiety by using the STAI questionnaire (Spielberger et al., 1983). To identify the possibility of discriminating between groups using four affective variables (positive word, negative word, positive picture, negative picture), a first discriminant function was conducted on affective memory performance. The discriminant function revealed a significant global Wilks' Lambda $\lambda = 0.495$, $x^2(4) = 25.324$, $p < 0.001$, which meant that these variables can be used to distinguish between the two groups as defined by the STAI questionnaire. As shown in Table 3, the classification results post-discriminant analysis implied that participants could be accurately classified to the extent of 80%.

4. Discussion

The current study examined the effect of health status and stimulus type on affective working memory performance. A significant interaction was found between anxiety, stimulus type, and valence of the stimulus. Overall, participants with anxiety demonstrated worse recognition rates than the healthy group. The effect was different for stimuli with different valences. Participants with anxiety had poorer recognition of stimuli with a positive valence, which was similar to healthy participants' recognition of stimuli with negative and neutral valence. The results are in line with those of previous studies (Fales et al., 2010; Romano et al., 2020). Herrera et al. (2017) proposed that this negative effect did not occur due to a memory processing preference but due to inhibition, and that this positivity inhibition made it difficult for participants with anxiety to memorize positive stimuli.

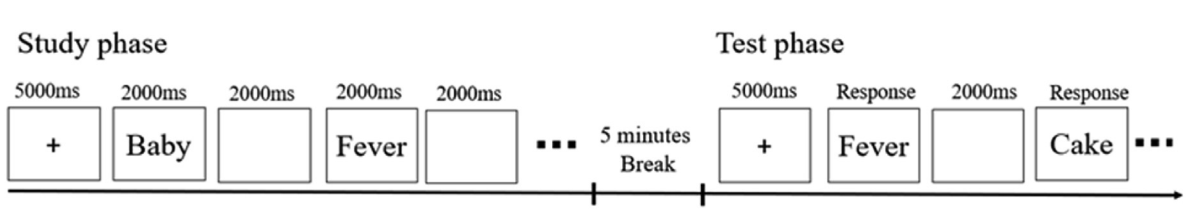

Figure 1. Affective recognition memory task flow.

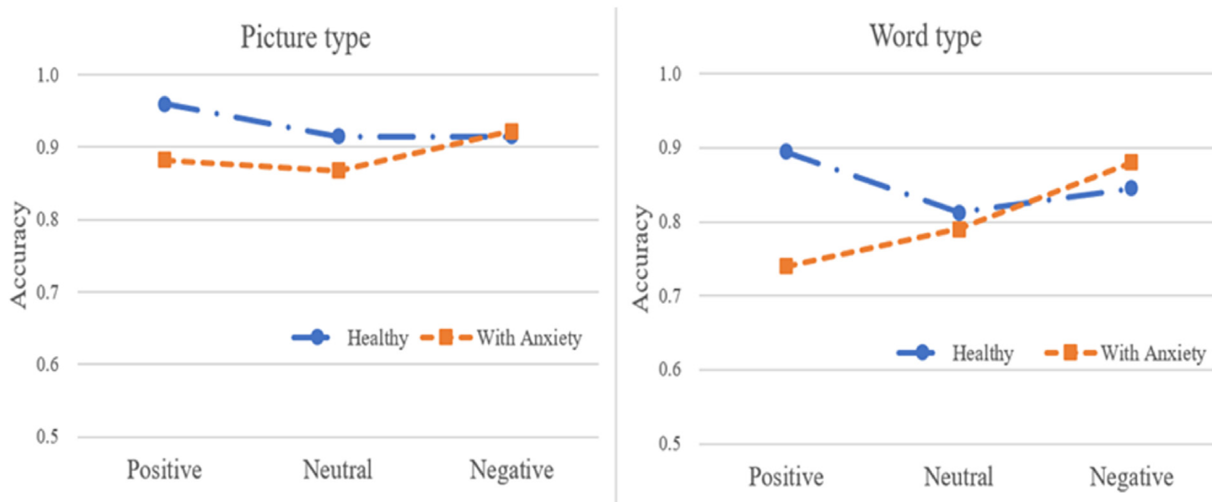

Figure 2. Accuracy in the recognition task as a function of the type and valence of the stimulus, and the participants' health status.

Table 2. Correlation coefficients of affective memory in relation to State-Trait Anxiety Inventory Scores.

Stimulus Types	Valence	State-Trait Anxiety Inventory	
		State	Trait
Word	Positive	-.515**	-.545**
	Neutral	-.052	-.011
	Negative	.167	.166
Picture	Positive	-.271	-.257
	Neutral	-.135	-.141
	Negative	.273	.447

*$p < 0.05$, **$p < 0.01$.

Table 3. Original and classification results.

Case count and Percentage		Health status		Total
		Healthy	with Anxiety	
Cross-validated count	Healthy	18	2	20
	with Anxiety	6	14	20
Cross-validated percentage	Healthy	90	10	100
	with Anxiety	30	70	100

80% of the organization grouped cases are correctly classified.

However, our studies found that the effect was present with words stimulation but not with picture stimulation. Participants with anxiety have an impaired amygdala, and this impairment prevents them from effectively carrying out affective stimulation (Engen and Anderson, 2018; Schweizer et al., 2019), especially for positive stimuli. However, the results of this study demonstrated that there was no difference between the positivity and negativity of picture stimulation in the anxiety group, indicating that pictures promote the performance of positive stimuli in the anxiety group. Waters et al. (2013) used positive pictures to conduct an attention bias modification training and the results revealed that it improved the anxiety severity of participants. We expound that this is because the features or components of positive pictures may induce positive attention bias so that more visual processing resources would be allocated to the positive pictures.

The results demonstrated that participants performed better at pictures than words, which indicates that affective pictures may promote affective working memory performance. The study of De Houwer and Hermans (1994) also revealed that participants processed the affective information in pictures faster than the affective information in words. Their results suggested that pictures contain affective information that is represented in a semantic network and that participants can access this semantic information through the pictures. Compared to the word stimuli, the affective pictures activated not only visual processing but also semantic processing; thus, the participants could effectively memorize the picture stimuli. The emotion label of the affective pictures could facilitate the participants' ability to process them effectively (Wu et al., 2020). This result is in line with the current study finding that participants with anxiety performed better on both positive pictures and negative pictures than affective words.

The effect size of the difference between the negative and neutral pictures in the anxiety groups was larger than that between the negative and positive pictures, which indicates that the affective working memory performance of the participants with anxiety was significantly influenced by the affective pictures, which had an emotion label. Conversely, the current study's results demonstrated that participants displayed a high level of accuracy for the recognition of the positive pictures compared with the neutral and negative pictures. Cabrera et al. (2020) proposed that healthy participants preferred to focus their attention on positive stimuli and avoided attending to negative stimuli. Due to more selective attention resources being used for the positive stimuli, healthy participants exhibited a positive bias toward affective working memory. In addition, the effect size of the difference between the positive and neutral pictures in the healthy groups was larger than that between the positive and negative pictures, which suggests that the affective working memory performance of the healthy participants was significantly influenced by the positive valence.

A similar interaction was exhibited between health status and the valence of the affective words. The effect size of the difference between the types of health status was larger for positive words than for positive pictures, which indicates that people are more sensitive to positive words when evaluating differences according to health status. Furthermore, the effect size of the difference between the types of valence of the word stimuli was larger than that of the picture stimuli. This suggests that the participants' affective working memory performance was significantly influenced by the valence of the words. The performance of the healthy participants was influenced by positive words and the performance of the participants with anxiety was influenced by negative words. These results are similar to those of Lee and Knight (2009) who found that the stimulus type could influence affective working memory performance. Schweizer et al. (2019) also proposed that the nature of the affective stimuli, valence, task-relevant information, and the interactions between them may influence the affective information processing performance. Furthermore, discriminant analyses demonstrated that the affective working memory performance of different stimulus types and valences can be used to distinguish between healthy adults and adults with anxiety. It confirms that differences in affective working memory performance across stimulus types and valences are features of anxiety disorders.

To summarize, the current study demonstrated the effect of valence and the stimulus type on affective working memory and found that the affective working memory performance, which is a feature associated with non-pathological anxiety, is also a clinical characteristic. The affective stimuli in pictures enhance the affective working memory performance of participants with anxiety, even for positive pictures. Therefore, this study highlights the effect of anxiety, valence, and the stimulus type on the affective memory processing mechanism. However, there is a limitation to our study. The sample size was small and this study only explained the affective memory performance of adults with mild anxiety. Thus, the sample size should be enlarged to explain the details of the affective working memory processing mechanism. In the future, more studies are needed to elucidate the relationship between affective working memory performance and the severity of the anxiety.

Declarations

Author contribution statement

Chen-Wen Fang: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Wei-Ru Chen: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Min-Sheng Chen: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Ya-Fang Yu: Conceived and designed the experiments; Performed the experiments.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interests.

Additional information

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