



State anxiety in healthy people can increase their vulnerability to neutral but not to unpleasant distraction in working memory

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ABSTRACT

Unpleasant irrelevant events are known to negatively affect our capacity to maintain neutral but task-relevant information in working memory (WM). In parallel, anxiety biases our attentional responses to those stimuli that may be potentially threatening in order to adaptively enhance their detection and assessment. In this study, we investigated differences between healthy anxious and non-anxious volunteers while they performed a WM task in which neutral and unpleasant pictures were presented as distractors. Our results revealed that state anxiety could increase the interfering effect of neutral but not unpleasant distractors. These findings are discussed in regard to previous studies suggesting that anxiety and acute stress can decrease the level of specificity in the vigilance mechanism that serves to optimize the detection and evaluation of threats.

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La ansiedad estado en personas sanas puede aumentar su vulnerabilidad a la distracción neutra pero no a la desagradable en la memoria de trabajo

RESUMEN

Se sabe que los hechos desagradables irrelevantes influyen negativamente en nuestra capacidad para mantener en la memoria de trabajo información no emocional aunque importante para la tarea. Paralelamente, la ansiedad sesga nuestras respuestas atencionales a aquellos estímulos potencialmente amenazadores para, de este modo, mejorar adaptativamente su detección y valoración. En este trabajo hemos investigado las diferencias entre voluntarios sanos y ansiosos mientras realizaban una tarea de memoria de trabajo en la que se presentaban como distractores imágenes neutras y desagradables. Los resultados muestran que la ansiedad estado puede aumentar el efecto de interferencia de los distractores neutros pero no de los desagradables. Se comentan dichos resultados en relación a estudios anteriores que concluyen que la ansiedad y el estrés agudo pueden disminuir el nivel de especificidad en el mecanismo de vigilancia que sirve para optimizar la detección y evaluación de las amenazas.

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It is widely accepted that cognition can be influenced by emotion, probably due to the biologically relevant information (e.g., food or predators) contained in emotional stimuli (Anderson & Phelps, 2001; LeDoux, 1996; Ohman, Flykt, & Ludqvist, 2000). It has been proposed that such stimuli have the capacity to recruit cognitive resources (Lang, Bradley, & Cuthbert, 1998; Lang, Greenwald, Bradley, & Hamm, 1993), in particular attentional resources, so that we are able to

quickly detect them and efficiently respond when facing information that is directly linked to our survival (Bradley et al., 2003; Lang, Bradley, Fitzsimmons, et al., 1998; Morris, Ohman, & Dolan, 1998; Sabatinelli, Bradley, Fitzsimmons, & Lang, 2005). In the memory domain, it has been demonstrated that emotional materials are better remembered than non-emotional ones (Canli, Zhao, Brewer, Gabrieli, & Cahill, 2000). However, a number of studies in the last years have showed that the preferential access of emotional stimuli to our cognitive system can impair our cognitive performance when they are potentially distracting. Thus, unpleasant events have been reported as more distracting than neutral events when participants are maintaining non-emotional information in working memory

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(Anticevic, Repovs, & Barch, 2010; Chuah et al., 2010; Denkova et al., 2010; Dolcos, Diaz-Granados, Wang, & McCarthy, 2008; Dolcos & McCarthy, 2006). This phenomenon has been interpreted as the consequence of the competition between linked-to-survival distractors and task-relevant information for cognitive resources in the context of interference-based forgetting theories (Berman, Jonides, & Lewis, 2009). In that case, the deep processing of emotional stimuli would consume a significant part of the available attentional capacity, leaving insufficient resources for the actual ongoing task (Ellis & Ashbrook, 1988).

Although the attention bias to emotional stimuli is considered adaptive in healthy people, a number of pathological and non-pathological mood states can affect these dynamics, modifying the expected cognitive performance. In particular, anxiety and acute stress are known to induce a state of hypervigilance in which the detection and evaluation of potential threats is boosted (de Kloet, Joëls, & Holsboer, 2005; van Marle, Hermans, Qin, & Fernández, 2009). This state of hypervigilance is considered adaptive as it increases our chances of successfully dealing with dangers in those situations in which our survival is compromised. However, this attentional bias in favor of potentially threatening stimuli is accompanied by impairments in selective attention (Henderson, Snyder, Gupta, & Banich, 2012; Tanji & Hoshi, 2008) and increased vulnerability to distraction (Aston-Jones & Cohen, 2005; Braunstein-Bercovitz, Dimentman-Ashkenazi, & Lubow, 2001; Skosnik, Chatterton, Swisher, & Park, 2000).

Previous studies have shown that stress can impair WM performance (Arnsten, 2009; Luethi, Meier, & Sandi, 2008; Lupien, Gillin, & Hauger, 1999; Oei, Everaerd, Elzinga, van Well, & Bermond, 2006; Ramos & Arnsten, 2007; Schoofs, Preuss, & Wolf, 2008) and this has been related to the release of glucocorticoids (GCs) and their negative effect on WM (Elzinga & Roelofs, 2005; Lupien et al., 1999; Oei et al., 2006; Wolf et al., 2001).

In the present study we aimed to investigate whether state anxiety in healthy young volunteers can affect the cognitive control of emotional and neutral distraction when maintaining non-emotional information in WM. If anxiety and acute stress are able to induce a state of hypervigilance, both neutral and unpleasant distractors should recruit more attentional resources in anxious participants than in non-anxious volunteers. Also, unpleasant distractors should be more interfering than neutral pictures in the anxious participants, since anxiety and acute stress produce an attentional bias towards the detection and evaluation of potential threats.

Method

Participants

Thirty-four students from the Complutense University of Madrid and the Camilo José Cela University of Madrid (mean age 22.14 years and a range between 18 and 35 years) took part in the study. They had normal or corrected-to-normal vision. Eighteen participants were males (18-39 years old and a mean age of 22.16 years) and sixteen were females (18-33 years old and a mean age of 22.12 years). Before they performed the experimental task, they all completed the Spanish version of the Spielberger State-Trait Anxiety Inventory for Adults (Spielberger, Gorsuch, & Lushene, 2002) and the Beck Depression Inventory (Beck, Steer, & Brown, 2006) (see Table 1 for demographic information). Participants received course credits for their time.

Materials

Items at encoding and recognition stages consisted of colored images of neutral faces. An oval mask was applied along the contours

Table 1
Volunteers' demographic information

	Age	STAI-S	STAI-T	Anxiety score	BDI
All participants (n = 34)					
Mean	22.14	16.55	12.35	4.17	6.05
SD	4.55	8.64	8.05	4.58	5.92
Low Anxiety (n = 17)					
Mean	21.94	12.64	11.76	0.88	5.40
SD	5.86	5.64	5.91	0.60	4.28
High Anxiety (n = 17)					
Mean	22.35	20.41	12.54	7.47	5.40
SD	2.87	9.50	9.91	4.45	4.28

Note. STAI-S = Spielberger State-Trait Anxiety Inventory for Adults - state score; STAI-T = Spielberger State-Trait Anxiety Inventory for Adults - trait score; Anxiety Score = STAI-S score minus STAI-T score. Higher scores represent more anxiety at the moment of facing the WM task, with regard to trait anxiety; BDI = Beck Depression Inventory.

of the faces to remove ears and hair and avoid any potential non-face specific cues. A pair of faces was presented at the encoding stage while just one face was displayed at the recognition stage. Faces were counterbalanced across experimental conditions. For the interfering items presented at the maintenance period, 30 neutral and 30 unpleasant pictures were selected from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 2005) and matched in luminance, contrast, color, and figure-ground relationships (see Table 2 for mean normative values).

Table 2
Mean normative values of pictures used in the experiment and mean subjective ratings of those pictures by our volunteers

Condition	IAPS valence	IAPS arousal	Subjective valence	Subjective arousal
All participants (n = 34)				
Neutral	4.91 (0.35)	2.77 (0.38)	5.01 (0.37)	2.32 (1.17)
Unpleasant	2.39 (0.67)	6.23 (0.56)	2.50 (0.96)	6.54 (1.41)
Low anxiety (n = 17)				
Neutral			5.01 (0.34)	2.10 (1.03)
Unpleasant			2.82 (0.91)	6.39 (1.43)
High anxiety (n = 17)				
Neutral			5.00 (0.41)	2.53 (1.29)
Unpleasant			2.17 (0.91)	6.70 (1.43)

Note. Standard deviations are shown in parenthesis.

Procedure

A delayed-recognition WM paradigm with two experimental conditions, neutral and unpleasant distraction, was used. Each condition comprised 30 trials. Each trial began with a 1,000-ms intertrial interval (ITI), followed by the presentation of a pair of faces for 2000 ms (encoding phase). After a 1000-ms blank screen, an interfering stimulus was displayed for 2000 ms, followed by another 1000-ms blank screen (maintenance phase). Next, just one face appeared on the screen for 1500 ms, followed by a 500-ms blank screen (recognition stage). Participants had to decide whether or not the face at the recognition stage has been one of the two previously encoded, by pressing one of two keys (Figure 1).

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