The effects of task-irrelevant threatening stimuli on orienting- and executive attentional processes under cognitive load

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BACKGROUND

THREAT PRIORITIZATION IN ATTENTION AND THE UNDERLYING NETWORKS The attentional biases for threat (ABT) framework is useful for understanding the information-processing peculiarities associated with threats. Previous studies (Dolcos et al., 2020; Mogg & Bradley, 2018) suggested that the two key components of ABT are salience (or stimulus-driven orienting) and the executive control of attention.

PROCESSING OF THREATS IN NON-CENTRAL VISION Threatening stimuli often appear outside the direct line of sight. From an evolutionary perspective, therefore, threat detection is most important when it allows one to quickly identify something not already under direct inspection. In fact, some predatory-related features (e.g., movement, sinusoid shape) have been shown to be sufficiently processed in the periphery in spite of the declining performance of the peripheral visual field (Carrette et al., 2017; Gao, LoBue, Irving, & Harvey, 2017).

EFFECTS OF COGNITIVE LOAD Noticing an unexpected threatening stimulus is even more crucial when a person is experiencing high cognitive load, when our attention tends to lapse more easily (Head & Helton, 2014). Neuroimaging evidence showed that amygdala responses were more robust under high load for unattended emotionally charged stimuli (Pessoa et al., 2005). However, previous findings on the relationship of cognitive load and attentional bias for threats are mixed, and the volume of studies remains scarce to date.

THE PRIMARY AIM of our study was to test the effects of task-irrelevant unattended threatening stimuli on the two key components of ABT under varying conditions of cognitive load.

METHOD

PARTICIPANTS Forty-four university students volunteered (30 women), with a mean age of 21.5 (SD=2.87). The required sample size for this experiment was determined by computing estimated statistical power (f=0.40, β > 0.8) based on previous studies (e.g., Zsidó et al., 2019) using a similar paradigm.

STIMULI The visual search task consisted of searching for numbers (sequentially) in matrices that were created using a special matrix generator program (freely accessible from http://baratharon.web.elle.hu/nummatrx/). In the easy task, the numbers ranged from 1 to 10 and were randomly distributed amongst the rectangles. In the hard task, the numbers ranged from 1 to 35. See examples below for both the easy (left) and hard (right) tasks. For each trial, a task-irrelevant picture appeared in one of the eight possible spatial positions: each of the four corners of the screen and in/paranearof/paral/parafinal (12.5°) or far/paral/peripheral (24°) from the center.

The pictures used in this experiment as task-irrelevant distractors were taken from a previous study (Zsidó et al., 2019). Pictures were selected from three threat intensity levels (neutral, moderate, high) and we selected pictures (in equal proportions) from across animal and object categories. We used the ratings provided by the authors of the picture systems. The images were equalized on low-level perceptual features using the Spectrum, Histogram, and Intensity Normalisation and Equalisation (SHINE) Matlab toolbox (Willenbockel et al., 2010).

RESULTS

Three-way interaction (F(2,80)=4.61,p<.013,r2=0.13)

Task Difficulty x Threat Intensity (F(2,80)=5.75,p<.001,r2=0.10)

Task Difficulty x Threat Intensity (F(2,80)=8.56,p<.001,r2=0.16)

Three-way interaction (F(2,80)=6.37,p<.003,r2=0.12)

DISCUSSION

Our results supported the load theory of attention (de Fockert et al., 2001; Lavie, 2010); i.e., task-irrelevant interference was only present when the task was difficult, not when it was easy. Further, we found evidence for the previously coined arousal stimulation effect (Zsidó et al., 2019); i.e., the arousal level conveyed by the emotional picture seems to facilitate visual search performance. Regarding the behavioural results, the distracting effect of threatening images increased reaction times for finding the first number, but this was offset by an increase in arousal caused by the stimuli; overall search times were decreased for threatening images, presumably due to the increased arousal rendered by the threats. This is in line with the arousal stimulation effect. Further, our eye-tracking measures showed that participants fixated on threatening pictures later and for shorter durations compared to neutral images. Peripheral vision alone could be enough to identify an image as threatening (even if the specific nature of that threat was not recognized), resulting in the active inhibition of that spatial position (Carrette et al., 2017; Gao, LoBue, Irving, & Harvey, 2017). That is, it was possible for the participant to know that some threatening object is there but not recognize it specifically. Task-irrelevant threatening images are distracting because they tend to trigger the brainstem-amygdala-cortex alarm system in spite of top-down attentional control, sweeping the attentional focus from the task to the task-irrelevant image. At the same time, the presence of a threat increases the activity in the central arousal systems, offsetting the initial loss of time.

REFERENCES


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