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Congruent bodily arousal promotes the constructive recognition of emotional words

Anne Kever^{a,b,*}, Delphine Grynberg^c, Nicolas Vermeulen^{a,b}^a *Université catholique de Louvain (UCL), Psychological Sciences Research Institute (IPSY), 10, Place du Cardinal Mercier, 1348 Louvain-la-Neuve, Belgium*^b *National Fund for Scientific Research (F.R.S.–F.N.R.S.), Belgium*^c *Université Lille, CNRS, CHU Lille, UMR 9193 – SCALab – Sciences Cognitives et Sciences Affectives, F-59000 Lille, France*

A B S T R A C T

Considerable research has shown that bodily states shape affect and cognition. Here, we examined whether transient states of bodily arousal influence the categorization speed of high arousal, low arousal, and neutral words. Participants realized two blocks of a constructive recognition task, once after a cycling session (increased arousal), and once after a relaxation session (reduced arousal). Results revealed overall faster response times for high arousal compared to low arousal words, and for positive compared to negative words. Importantly, low arousal words were categorized significantly faster after the relaxation than after the cycling, suggesting that a decrease in bodily arousal promotes the recognition of stimuli matching one's current arousal state. These findings highlight the importance of the arousal dimension in emotional processing, and suggest the presence of arousal-congruency effects.

1. Introduction

Do emotional feelings have the power to influence our thinking and behavior? Research seems to indicate that this is the case. Numerous studies indeed provide evidence for interactions between affective and cognitive phenomena. For instance, past research revealed enhanced or facilitated processing of information that matches an individual's current affective state (Bower, 1981; Fiedler, 1990; Forgas, 1994). These so-called *mood congruency effects* have typically been observed in memory tasks, with positive materials recalled better when experiencing a pleasant mood, and negative materials recalled better when experiencing an unpleasant mood (for review, see Ellis & Ashbrook, 1989; Mayer, Gayle, Meehan, & Haarman, 1990). Moreover, findings indicate that transient emotional states influence processing speed for affectively loaded stimuli. Participants made faster lexical decisions (word versus nonword) for mood-congruent stimuli (e.g., “sad” words like *despair* or *regret* following sadness induction) (Niedenthal, Setterlund, Mondillon, & Vermeulen, 1997) and showed facilitated response latencies when evaluating mood-congruent pictures (e.g., categorizing a slide displaying flowers as positive when feeling elated) (Hermans, De Houwer, & Eelen, 1996).

Emotional congruency effects thus present a well-documented phenomenon in the literature. However, when taking a closer look, it becomes clear that prior studies primarily focus on the most universal, obvious feature of emotion, its valenced character. But emotions involve more than just a positivity-negativity dimension. They also vary along the dimension of arousal, indicating whether an emotional state or stimulus is rather calming or exciting (Feldman Barrett & Russell, 1999; Russell, 1980). According to Russell's

* Corresponding author at: Université catholique de Louvain (UCL), Psychological Sciences Research Institute (IPSY), 10, Place du Cardinal Mercier, 1348 Louvain-la-Neuve, Belgium.

E-mail addresses: anne.kever@uclouvain.be (A. Kever), delphine.grynberg@univ-lille3.fr (D. Grynberg), nicolas.vermeulen@uclouvain.be (N. Vermeulen).

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circumplex model of affect (1980), each emotion can be understood as a linear combination of these two dimensions, which are bipolar, orthogonal, and independent from each other. Fear, for example, is conceptualized as an affective state involving both negative valence and heightened levels of autonomic arousal. Similarly, positive and negative concepts can be judged as either highly arousing (e.g., *passion, terror*) or lowly arousing (e.g., *gentleness, boredom*). In support of this model, studies have indicated separate neural routes for the processing of valence and arousal (e.g., Colibazzi et al., 2010; Kensinger & Corkin, 2004; LaBar & Cabeza, 2006; Nielen et al., 2009), and have shown that valence and arousal can be conditioned independently (Gawronski & Mitchell, 2014).

Furthermore, previous research suggest that arousal value might play a critical role in word processing. Findings indeed indicated that highly arousing stimuli benefit from special attentional status (e.g., Anderson, 2005; Schimmack, 2005) and facilitated memory recollection compared to low arousal stimuli (e.g., Ochsner, 2000). Interestingly, findings also suggest that experienced arousal reactions provide information about the importance of an encountered stimulus (e.g., signaling personal relevance) and consequently guide our judgements and decisions (for review, see Storbeck & Clore, 2008). For instance, a series of classic experiments showed that increased arousal intensified judgements of attractiveness (Dutton & Aron, 1974), amusement (Martin, Harlow, & Strack, 1992), and, more recently, perceived height (Stefanucci & Storbeck, 2009).

However, when turning to congruency effects it becomes striking that previous studies have exclusively focused on valence features (i.e., positive/negative mood and processing of positive/negative stimuli), and this despite the undeniable importance of the emotional arousal dimension. Given this gap in the literature, the question rises whether congruency effects can also be observed when stressing the role of arousal in this context. More concretely, it remains largely unclear whether high/low levels of bodily arousal may influence the processing of high/low arousal emotional stimuli.

To date, little research has been undertaken to examine this issue and empirical evidence is correspondingly sparse. In 1984, Clark and collaborators investigated the influence of bodily arousal on judgments of other's emotions. Results revealed that highly aroused participants (i.e., after vs. before a tennis match) were more likely to interpret positive statements and facial expressions as indicating joy (a high arousal emotion) than serenity (a low arousal emotion). In other terms, participants' judgments seemed to be biased towards evaluations matching their current level of experienced arousal. Although the results of this study should be interpreted with caution (i.e., given a lack of reliable physiological and mood measurements), they point towards a possible facilitating effect of a congruent arousal state on emotional stimuli processing. In subsequent years, the question of arousal congruency remained largely outstanding, with new insights having only been provided very recently. Current findings indeed suggest that actual levels of bodily arousal modulate the cognitive access to arousal (in)congruent stimuli in an attentional blink paradigm (Kever et al., 2015). The attentional blink paradigm requires the report of two targets (T1 and T2) presented within a stream of distractor items. The ability to report the second target (T2) is typically impaired if it appears 200–500 ms after the first to-be-detected target (T1) (Raymond, Shapiro, & Arnell, 1992). While early theories attribute the attentional blink effect to capacity limitations or a bottleneck (e.g., Chun & Potter, 1995; for review, see Dux & Marois, 2009), a more recent account assigns it to a gating system that promotes (“boosts”) the entrance of relevant information (a target) and hampers (“bounces”) the entrance of irrelevant information (a distractor) into working memory (Olivers & Meeter, 2008). Previous results showed that increased bodily arousal (i.e., following a cycling session) led to improved reports of high arousal T2 words, whereas reduced bodily arousal (i.e., following a relaxation session) led to improved reports of low arousal T2 words. It can thus be suggested that arousal-congruent words enjoy facilitated access to the working memory space, increasing the possibility that they get accurately reported (Kever et al., 2015; Vermeulen, Chang, Mermillod, Pleyers, & Corneille, 2013; Vermeulen, Mermillod, Godefroid, & Corneille, 2009).

In view of these promising preliminary findings, further studies are clearly needed to determine more specifically under which conditions arousal congruency effects can be observed. While research suggests that arousal-congruent stimuli enter working memory more easily, it remains unclear whether these stimuli can also be more easily retrieved. In an attempt to solve this issue, the present study examines whether changes in overall bodily arousal influence the recognition and categorization of high and low arousing words when active elaboration is required to access word meaning (Fiedler, Nickel, Muehlfriedel, & Unkelbach, 2001; Kever, Szmalec, Grynberg, & Vermeulen, submitted for publication). Concretely, we relied on a constructive recognition task (CRT), in which a target word is first hidden by a mask and then becomes progressively visible (Fiedler et al., 2001). While the attentional blink paradigm reflects the temporal costs in allocating selective attention (Dux & Marois, 2009), the CRT complexifies visual analysis by slowly revealing word fragments, and consequently invites for active, knowledge-based inferences to complete or generate the meaning of the emerging stimulus (Fiedler et al., 2001). The CRT thus presents a pronounced top-down component requiring to draw semantic inferences beyond the information given. These generative features make it an appropriate paradigm to investigate whether arousal-congruency effects can not only be observed under limited attentional resources when information is fully presented (i.e., attentional blink), but also when information is actively constructed (i.e., CRT) based on previous memory-stored knowledge (retrieval).

Here, participants' level of physiological arousal was modified by means of a short cycling and relaxation session (Kever et al., 2015). Following each session, participants realized a CRT block, with targets being high arousal (positive and negative), low arousal (positive and negative), and neutral words (non-emotional control items). This way, potential interactions between bodily arousal and word arousal could be determined reliably. Based on the assumption of an arousal-congruency effect, we hypothesize that increased physiological arousal (i.e., post-cycling) leads to faster categorization of high arousal words, while reduced physiological arousal (i.e., post-relaxation) leads to faster categorization of low arousal words. Recognition times for neutral words, however, should not be affected by the physiological arousal conditions.

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