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Prime visibility moderates implicit anger and sadness effects on effort-related cardiac response

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ABSTRACT

Based on the Implicit-Affect-Primes-Effort (IAPE) model (Gendolla, 2012, 2015), an experiment investigated the effect of affect primes' visibility on effort mobilization during cognitive processing. Participants worked on a short-term memory task with integrated sadness vs. anger primes that were presented suboptimally (briefly and masked) vs. optimally (long and visible). Effort was assessed as cardiovascular response, especially cardiac pre-ejection period (PEP). To monitor performance, we assessed response accuracy and reaction times. In accordance with the IAPE model, PEP reactivity was stronger in the sadness-prime condition than in the anger-prime condition—but only when the primes were suboptimally presented. Effects on response accuracy revealed a corresponding pattern. The results suggest that prime visibility is a boundary condition of anger and sadness primes' effect on effort mobilization.

1. Introduction

The mere implicit activation of knowledge *about* affective states is sufficient to influence resource mobilization during cognitive processing. Research in the context of the Implicit-Affect-Primes-Effort (IAPE) model (Gendolla, 2012, 2015), has revealed replicated evidence that affective stimuli that are implicitly processed during cognitive tasks systematically influence effort-related responses in the cardiovascular system. The IAPE model builds on the idea that effort mobilization is grounded in a resource conservation principle. Consequently, effort is mobilized proportionally to subjective demand as long as success is possible and justified (Brehm & Self, 1989). By learning that coping with challenges is easier in some affective states than in others, performance ease or difficulty become features of individuals' mental representations of different affective states. Implicit affect primes can automatically activate that knowledge which then influences resource mobilization.

More specifically, the IAPE model posits associations between sadness and fear with difficulty, and of happiness and anger with ease. This occurs because people should learn that performing tasks in a sad mood is subjectively more demanding than performing tasks in a happy mood (e.g. De Burgo & Gendolla, 2009; Gendolla & Brinkmann, 2005; Gendolla & Krüsken, 2002). Consequently, ease becomes a feature of the mental representation of happiness, while difficulty becomes a feature of the mental representation of sadness. People should also learn to associate fear with difficulty and anger with ease. This is because anger is linked to optimism, positive expectations, and experiences of high coping potential (Lerner & Keltner, 2001)—the feeling of efficiency relative to a task (Scherer, 2009)—which reduces subjective difficulty (Wright & Dismukes, 1995). Conversely, fear is associated with pessimism, low control, and low coping potential (Lerner & Keltner, 2001). Correspondingly, anxiety has been shown to have negative effects on different types of cognitive performance (e.g., Byron & Khazanchi, 2010; Cassaday & Johnson, 2002), meaning that fear is associated with obstacles and thus difficulty.

The IAPE model predictions have been tested using suboptimally[1] (i.e. briefly and masked) presented affect primes and were supported by several studies. As expected, in relatively easy and moderately difficult tasks, suboptimal sadness and fear primes led to stronger effort-related cardiovascular response than happiness and anger primes (e.g., Chatelain & Gendolla, 2015; Gendolla & Silvestrini, 2011; Lasauskaite, Gendolla, & Silvestrini, 2013).

1.1. Prime visibility

Recent research suggests that priming effects on behavior depend on

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[1] We use the term suboptimal rather than subliminal, because the latter refers to stimulus presentations below individually determined thresholds of conscious perception. In our research, low contrast affective stimuli are briefly presented (25 ms) and backward masked resulting in suboptimal presentation in order to prevent controlled processing of the primes' content.

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individuals' unawareness of primes' presence or influences. Automaticity seems to hinge on individuals' belief that their actually primed mental content is a valid basis for their behavior (e.g., Loersch & Payne, 2012; Wheeler, DeMarree, & Petty, 2007). For this, individuals have to be unaware that their thoughts have been influenced by external stimulation. Clearly visible affect primes that have nothing to do with a currently performed task do not fulfill this criterion. Thus, such visible primes should induce suspicion and result in behavior correction (Gendolla, 2015). Likewise, doubt or lack of confidence (DeMarree et al., 2012) and warning people of prime appearance were identified as boundary conditions of behavioral priming (Loersch & Payne, 2012; Verwijmeren, Karremans, Bernritter, Stroebe, & Wigboldus, 2013).

Apparently, the automatic processes that are activated by implicit priming are interrupted and modified when people become aware of being primed. Indeed, if people prefer autonomy and think that they act in accordance with their own decisions (Ryan & Deci, 2000), they should dislike being manipulated and react to perceived external influences (Brehm, 1966) with behavior correction.

Recent studies found that the effects of happiness and sadness-related primes on objective measures of resource mobilization were moderated by prime visibility (Chaillou, Giersch, Bonnefond, Custers, & Capa, 2015; Lasauskaite Schüpbach, Gendolla, & Silvestrini, 2014). Compared with masked affect primes, prime visibility led to attenuated or even reversed effects in these studies. This leads to the important question whether prime visibility is a general moderator of affect primes' effects on effort mobilization. Understanding the moderator and boundary conditions of prime effects on behavior is essential for understanding the conditions of automaticity.

1.2. Effort-related cardiovascular response

Wright (1996) has integrated motivational intensity theory (Brehm & Self, 1989) with the active coping approach (Obrist, 1981), leading to the prediction that beta-adrenergic sympathetic impact on the heart increases with subjective task difficulty as long as success is possible and justified. Beta-adrenergic activity especially influences cardiac contractility, which is reflected by pre-ejection period (PEP)—the time interval (in ms) between the onset of left ventricular depolarization and the opening of the left aortic valve (Berntson, Lozano, Chen, & Cacioppo, 2004). PEP becomes shorter as cardiac contractility force increases and is sensitive to variations in perceived task demand (e.g., Richter, Friedrich, & Gendolla, 2008), incentive (e.g., Richter & Gendolla, 2009), and combinations of both variables (e.g., Silvestrini & Gendolla, 2011a).

Due to the systematic impact of cardiac contractility on cardiac output (the volume of blood pumped by the ventricular per minute), several studies also used systolic blood pressure (SBP) to measure effort (see Gendolla & Richter, 2010; Wright & Gendolla, 2012; Wright & Kirby, 2001 for overviews). However, PEP is the more reliable measure of effort mobilization, because it can directly mirror beta-adrenergic sympathetic impact (Kelsey, 2012). SBP and DBP (diastolic blood pressure) are additionally influenced by peripheral vascular resistance, which is not systematically influenced by beta adrenergic activity (Levick, 2003). Heart rate (HR) is controlled by both sympathetic and parasympathetic impact and should reflect effort mobilization only if the sympathetic activation is stronger (cf. Berntson, Cacioppo, & Quigley, 1993). Nevertheless, HR and blood pressure should always be assessed together with PEP to control for possible preload (ventricular filling) and afterload (arterial pressure) effects on PEP (Sherwood et al., 1990).

1.3. The present experiment

Participants worked on a short-term memory task during which they were exposed to sadness vs. anger primes. To test whether prime awareness is a boundary condition of implicit affect's impact on effort-related cardiovascular response, the primes were presented suboptimally (25 ms) for half of the participants vs. optimally (775 ms) for the other half, resulting in a 2 (Prime: sadness vs. anger) × 2 (Visibility: suboptimal vs. optimal) between-persons design. We expected a Prime × Visibility interaction effect on effort. In the suboptimal prime presentation condition, where the affect primes were processed automatically, sadness primes should lead to stronger PEP reactivity than anger primes—as predicted by the IAPE model (see Gendolla, 2012) and supported by previous studies (e.g., Chatelain & Gendolla, 2015; Gendolla & Silvestrini, 2011). The reason is that sadness is associated with performance difficulty (low coping potential) while anger is associated with ease (high coping potential; see Lerner & Keltner, 2001). Importantly, this affect prime effect should be moderated in the optimal prime presentation condition. Here, controlled prime processing was possible, producing a prime-zero effect reflecting behavioral correction or even a prime contrast effect in the case of overcorrection (Gendolla, 2015), as previously found in studies with affect primes of positive vs. negative valence (e.g., Chaillou et al., 2015; Lasauskaite Schüpbach et al., 2014). To further test whether the prime visibility moderation effect is emotion-specific rather than-valence specific, this experiment administered only affect primes of negative valence, which should have different effects on effort mobilization according to the IAPE model. Finding evidence for the here tested hypotheses would make it implausible to attribute the previous findings of a moderation of affect primes' effect on effort mobilization to the valence of implicit emotions.

2. Method

2.1. Participants and design

To collect valid data of at least 20 participants per condition (Simmons, Nelson, & Simonsohn, 2011) we randomly assigned 87 university students (71 women, average age 20.46 years) to the conditions of the 2 (Prime: sadness vs. anger) × 2 (Visibility: suboptimal vs. optimal) between-persons design. 4 participants were removed—3 took cardiac, antidepressant, or anxiolytic medication and 1 did not follow the task instructions—leaving a final sample of $N = 83$. The gender distribution was balanced, with 4 men and 16–17 women in each condition.

2.2. Affect primes

We used grey-scale, low frequency, front perspective face pictures from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998) as affect primes, showing averaged neutral (MNES, FNES), sadness (MSAS, FSAS), and anger (MANS, FANS) expressions (50% male, 50% female faces).

2.3. Apparatus and physiological measures

We noninvasively measured impedance cardiogram (ICG) and electrocardiogram (ECG) signals with a Cardioscreen 1000 system (medis, Ilmenau, Germany) to assess HR and PEP. Four pairs of medis Ag/AgCl electrodes were placed on the left and right side of participants' neck and on the left and right middle axillary line at the height of the xiphoid. Signals were amplified and digitalized (sampling rate 1000 Hz), and analyzed offline (50 Hz low pass filter) with BlueBox 2.V1.22 software (Richter, 2010). The first derivative of the change in thoracic impedance was calculated, and the resulting dZ/dt signal was ensemble averaged in 1-min intervals. B-point location was estimated based on the RZ interval of valid heart beat cycles (Lozano et al., 2007), visually inspected, and if necessary corrected as recommended (Sherwood et al., 1990). PEP (in ms) was determined as the interval between R-onset and B-point (Berntson et al., 2004). HR was determined on the basis of IBIs assessed with the Cardioscreen system. Additionally, we oscillometrically assessed SBP and DBP in 1-min