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Research Paper

On the implicit influence of pain cues on cognitive effort: Evidence from cardiovascular reactivity

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ABSTRACT

To extend previous findings on the impact of implicit affect on behavior, two experiments investigated the influence of priming pain cues on cognitive effort. Effort was assessed as cardiovascular reactivity (PEP, SBP, DBP, and HR) during an easy or difficult cognitive task integrating briefly presented and masked pain-related words. The control condition included neutral words (Experiment 1) or anger-related words (Experiment 2). The pain primes were expected to increase the perceived difficulty of the task and to result in stronger effort during the easy task, compared to the control condition, and to lower effort during the difficult task, due to disengagement. Overall, cardiovascular reactivity of both experiments supported the predictions. Moreover, pain primes increased self-reported subjective difficulty. Finally, most participants could not report the content of the primes. Findings are discussed regarding the influence of implicit processes in pain experience and regarding the self-regulatory consequences of the influence of pain on effort mobilization.

1. Introduction

Accumulating evidence indicates that implicit processes, broadly defined as processes that are automatic (see De Houwer & Moors, 2012), have a reliable influence on behavior (see Bargh & Chartrand, 1999; Custers & Aarts, 2005; Dijksterhuis & Aarts, 2010; Hassin, Uleman, & Bargh, 2004, for reviews). Although methodological issues and empirical findings on priming are currently highly debated (Weingarten et al., 2016), it is reasonable to conceive that individuals have to handle most of the complex and abundant surrounding information in an automatic way due to the limitations of conscious processing (e.g., Norman & Shallice, 1986; Posner & Snyder, 1975; Shiffrin & Schneider, 1977). Therefore, understanding and predicting how implicitly processed stimuli can influence behavior represents an important issue in modern psychology.

Besides attitudes, stereotypes, and goals, priming research also found evidence for a behavioral influence of implicit affect (e.g., Gendolla & Silvestrini, 2011; Winkielman, Berridge, & Wilbarger, 2005), which can be defined as the automatic activation of mental representations associated with affective states (Quirin, Kazén, & Kuhl, 2009). However, as presented in more details below, mainly basic emotions, such as joy, sadness, anger, or fear, have been investigated so far. The aim of the present research is to extend these findings to the phenomenon of pain, which includes a strong affective component, is crucial for survival, and involves huge human and economic costs (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006). To investigate the implicit influence of pain cues on behavior, the present research focused on effort, defined as the amount of resources people mobilize to execute instrumental behavior (Gendolla & Wright, 2009), and assessed cardiovascular reactivity as a measure of effort mobilization (Wright, 1996).

1.1. Implicit affect and effort

Previous research found reliable evidence for an influence of implicit affect on effort mobilization during cognitive tasks (e.g., Freydefont, Gendolla, & Silvestrini, 2012; Gendolla & Silvestrini, 2011; Lasauskaite Schüpbach, Gendolla, & Silvestrini, 2014). A recent theoretical framework, the implicit-affect-primes-effort model (IAPE model; Gendolla, 2012, 2015), provides a rationale and predictions for this influence. According to this model, implicit affect influences the perceived difficulty of the task at hand, which determines in turn effort mobilization as predicted by motivational intensity theory (Brehm & Self, 1989).

The rationale of this model is that individuals learn during their lifetime that performing cognitive tasks is harder in some affective states than in some others. For instance, individuals experience that performing a task while in a sad mood is more difficult than in a joyful mood (see Brinkmann & Gendolla, 2008). Accordingly, the IAPE model predicts that the concept of sadness is associated in memory with the concept of difficulty whereas the concept of joy is associated with the

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concept of ease. When these affective concepts are implicitly activated during task performance, for instance by means of priming, it is expected that the concepts of difficulty or ease are also activated and become more accessible. This increased accessibility is predicted to influence the judgment of task difficulty, which, as other judgments, is determined by all accessible information (see Bower, 1981). In turn, subjective difficulty influences effort as predicted by motivational intensity theory (Brehm & Self, 1989), which postulates that, when task difficulty is fixed and known, effort is determined by subjective difficulty as long as success is possible and the required effort is justified.

The IAPE model proposes that sadness and fear are associated with the concept of difficulty, whereas joy and anger are associated with ease. Interestingly and importantly for the present research, anger is predicted to be associated with ease because despite its negative valence, anger is typically linked with experiences of high coping potential, which is predicted to lead to lower perceived difficulty. The predictions related to these basic emotions were supported by a series of empirical studies (Chatelain & Gendolla, 2015; Chatelain, Silvestrini, & Gendolla, 2016; Freydefont & Gendolla, 2012; Freydefont et al., 2012; Gendolla & Silvestrini, 2011; Lasauskaite Schüpbach et al., 2014; Silvestrini & Gendolla, 2011). However, the model aims to apply to any affective states that are associated with ease or difficulty. As presented in the next section, the present research draws on the assumption that pain can be considered as an affective state associated with difficulty.

1.2. Priming pain and effort

Pain is currently defined as an unpleasant sensory and emotional experience (Merskey, 1986), which clearly indicates that pain can be considered as an affective state. Moreover, reliable evidence shows that pain impairs concomitant cognitive performance (e.g., Buhle & Wager, 2010). This effect suggests that pain and cognitive performance engage common and limited cognitive resources and that pain can be considered as an additional demand on these resources leading to performance impairment. Consequently, it is expected that performing a task when experiencing pain is perceived as harder than performing the same task without pain, and that individuals have learned this association through a semantic link in memory between the concept of pain and the concept of difficulty. Therefore, based on the rationale of the IAPE model, implicitly activating the concept of pain in the context of task performance should jointly activate the concept of difficulty, which should become more accessible, increase subjective task demand, and influence in turn effort mobilization. This prediction was tested for the first time in a recent study investigating the influence of implicitly activating the concept of pain on effort mobilization assessed as cardiovascular reactivity (Silvestrini, 2015).

In this study, participants were exposed to pain-related or neutral words primed during a difficult cognitive task. Moreover, they could earn a high or a moderate incentive in case of success in the task. Cardiovascular reactivity was assessed during a habituation period and during task performance. Results fully supported the predictions. Participants exposed to pain primes mobilized more effort when they had the opportunity to receive a high incentive in case of success compared to the low incentive condition where they disengaged. Participants primed with neutral words invested a moderate effort regardless of the incentive condition. Moreover, participants perceived themselves as less capable to perform the task when primed with pain cues than with neutral cues. These findings were interpreted as showing that pain primes increased perceived task difficulty leading to higher effort than neutral primes when the high incentive justified this effort and to disengagement when incentive did not justify the required effort. Therefore, these findings supported the predictions of the IAPE model applied to pain. To replicate these findings and to further test the impact of pain primes on effort mobilization, the two present experiments manipulated task difficulty instead of task incentive and assessed cardiovascular reactivity as a measure of effort mobilization.

1.3. Effort mobilization and cardiovascular reactivity

In more than hundred studies, cardiovascular parameters have been used to assess effort mobilization during cognitive tasks (see Gendolla & Wright, 2005; Gendolla, Wright, & Richter, 2012; Wright & Kirby, 2001, for reviews). This approach was first proposed by Wright (1996) who integrated the predictions of motivational intensity theory (Brehm & Self, 1989) together with the work of Obrist (1981) on cardiovascular psychophysiology. This line of research showed that especially sympathetic activity on the heart reflects effort mobilization in active goal pursuit and this was further supported by a recent integrative approach on the neural mechanisms associated with effort-related cardiovascular activity and cognitive control (Silvestrini, 2017). Therefore, as in previous studies using this paradigm, the present experiments rely on cardiovascular parameters mainly influenced by sympathetic activity on the heart to assess effort. Among them, the pre-ejection period (PEP; the time interval between the onset of ventricular depolarization and the opening of the aortic valve) is the non-invasive parameter that is most directly influenced by sympathetic activity on the heart through heart contractility (e.g., Newlin & Levenson, 1979). Also systolic blood pressure (SBP; the maximal pressure between two heartbeats) is determined by heart contractility and has been used in many studies using this paradigm. However, PEP represents a more direct measure of sympathetic activity on the heart than SBP because SBP is more strongly influenced by peripheral resistance than PEP. Diastolic blood pressure (DBP; the minimal pressure between two heart beats) and heart rate (HR; the number of beats per minute) are still less sensitive to myocardial sympathetic activity due to the influence of peripheral resistance and parasympathetic activity, respectively. However, DBP and HR should always be assessed together with PEP to control for pre-load and after-load effects on PEP reactivity (Sherwood et al., 1990).

1.4. The present experiments

In the two present experiments, participants worked on an objectively easy vs. difficult short-term memory task adapted from Sternberg (1966). During the task, participants were exposed to briefly presented (53 ms) and masked words related to pain vs. neutral words (Experiment 1) or vs. anger words (Experiment 2) as the control conditions. Participants primed with pain words were predicted to perceive the task as more difficult than in the control condition. Accordingly, cardiovascular reactivity—especially PEP and SBP reactivity—was predicted to be stronger in the pain/easy condition than in the control/easy condition, due to the increased difficulty induced by the pain primes. In contrast, a very low reactivity was expected in the pain/difficult condition. Here, the objective difficult condition and the increased difficulty induced by the pain primes were predicted to result in a too high subjective difficulty. This too high subjective difficulty was expected to lead to very low effort because the high required effort was not justified by task importance resulting in disengagement. A stronger reactivity was expected in the control/difficult condition due to the objectively difficult task leading to high but not too high subjective difficulty. These predictions on effort are presented in Fig. 1.

DBP and HR were expected to show a similar but presumably weaker pattern than PEP and SBP because they are less sensitive to myocardial sympathetic activity. Given that performance in a task also depends on variables such as ability and strategy, and not only on exerted effort (Locke & Latham, 1990), predictions for task performance were not straightforward as those for effort. Task performance may reflect the predicted effort but could also be influenced by other factors. For instance, priming the concept of pain could mainly impair task performance as physical pain (Buhle & Wager, 2010), and as found in a previous study (Silvestrini, 2015).