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Running Head: Affect Prime Visibility and Effort

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.

Key Words: Implicit Affect, Effort, Automaticity, Cardiovascular

Highlights

- Participants worked on a short-term memory task and were presented with masked vs. visible facial expressions of sadness vs. anger
- As predicted by the IAPE model, reactivity of cardiac pre-ejection period was stronger in the sadness-prime condition than in the anger-prime condition, but only when the primes were masked.
- Prime visibility was a boundary condition of implicit affect's effect on effort mobilization.

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 found 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 individual's 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 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).

Prime Visibility

Recent research suggests that priming effects on behavior depend on 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 (DeMaree 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 Schüppbach, 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.

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, and 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 the 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 (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).

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) x 2 (Visibility: suboptimal vs. optimal) between-persons design. We expected a Prime x 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 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.

Method

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) x 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.

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).

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 intervals with a Dinamap ProCare monitor (GE Healthcare, Milwaukee, WI). The blood pressure cuff was placed over the brachial artery above the elbow of participant's non-dominant arm. Assessed values were stored on computer disk.

Procedure

The experiment was approved by the local ethics committee. Participants were seated in a comfortable chair, gave signed consent, and were equipped with the physiological sensors. After answering biographical questions (age, sex, etc.), participants rated their affective state before the exposure to the affect primes (2 sadness items: down, sad; 2 anger items: angry, irritated) on 7-point scales (1—*not at all*, 7—*very much*). Next, they saw a hedonically neutral documentary film about Portugal (8 min) to assess cardiovascular baseline values, followed by a Sternberg-type short-term memory task (5 min) during which we assessed performance-related cardiovascular activity.

Participants were instructed to respond correctly and as fast as possible. 36 Trials started with a fixation cross (1000 ms), followed by a face picture (affect prime) that centrally appeared for 25 ms (suboptimal condition) vs. 775 ms (optimal condition), a grey random dot picture mask (133 ms), and a second fixation cross (1000 ms). Emotional faces were presented in only 1/3 of the trials (in the other 2/3, neutral faces appeared) to prevent habituation effects (Silvestrini & Gendolla, 2011b). After the second fixation cross disappeared, four letters appeared at the screen's center (750 ms) and were masked by a row of the letter "X" with a target letter on top. Participants had to decide within 2000 ms if the target letter was part of the previously presented letter string or not by pressing respective response keys with the middle and index fingers of their dominant hand. After responding, the message "response entered" or—in case of no response within 2000 ms "please answer more quickly"—appeared for 4 sec. minus participants' reaction time in the suboptimal condition. In the optimal condition, the presentation time of this message was 750 ms shorter to assure that trials in both prime presentation condition had the same duration. The inter-trial interval lasted from 1000 to 3000 ms.

Before the task, participants completed 12 practice trials with only neutral facial expressions as primes and response correctness feedback. After the task participants rated subjective task difficulty, success importance, and the same affect items as at the procedure's onset (1—*not at all;* 7—*very much*) and indicated possible medication and their cardiovascular health status. Finally, we ran a standardized funnel debriefing procedure asking participants about the study's purpose and what they had seen during the trials. Participants who mentioned "flickers" were asked to describe their content.

Results

Cardiovascular Baselines

Repeated measures ANOVAs of the 1-min cardiovascular activity scores of the habituation period revealed time effects on all indices, *Fs* > 5.09, *ps* < .001, $\eta^2 \geq .06$, reflecting higher activity at the beginning. HSD Tukey tests revealed that the last four minutes for PEP (*p*s > .188), the last three minutes for SBP (*p*s > .078), the last two minutes for DBP (p = .422), and the last three minutes for HR (p > .12) did not differ significantly and showed high internal consistency (Cronbach's αs > .88). Therefore, we constituted cardiovascular baseline values based on these periods (Table 2).[2] Baseline values did not significantly differ between the experimental conditions (*p*s > .235).

Cardiovascular Reactivity

We created reactivity scores by subtracting participants' baseline values from their five 1-min scores of cardiovascular activity during task performance. Repeated measures ANOVAs yielded significant time effects on all indices, *Fs* > 5.49, *ps* < .001, η^2 >. 06, and contrasts revealed significantly stronger reactivity during the first task minute than during the rest, *Fs* > 7.82, *ps* < .006, η^2 > .08, suggesting early disengagement. Thus, we focused our analysis of cardiovascular reactivity on the first task minute. Preliminary ANCOVAs did not find significant associations between baseline and reactivity scores (*ps* > .070).

PEP Reactivity

A 2 (Prime) × 2 (Visibility) between-persons ANOVA revealed a significant interaction, $F(1,79) = 4.07$, $p = .047$, $\eta^2 = .05$, 95% CI [0.07, 10.38]. As depicted in Figure 1, the PEP response pattern corresponded to the predictions: in the suboptimal-prime-presentation condition, participants primed with sadness showed the expected stronger PEP reactivity (M = -6.23, SE = 1.83) than those primed with anger (M = -2.54, SE = 1.02), $t(79) = 2.00$, $p = .024$, $\eta^2 = .05$, 95% CI [0.62, infinity].[3] In the optimal-prime-presentation condition, the means of the sadness-prime (M = -2.87, SE = 0.94) and anger-prime (M = -4.40, SE = 1.18) conditions described the opposite pattern, but did not differ significantly (p = .401). Thus, visibility bounded the affect primes' effect on effort-related cardiac response.

SBP, DBP, and HR Reactivity

As presented in Table 3, also the patterns of the other cardiovascular indices' cell means corresponded to our effort-related predictions, but the interaction effects on SBP (p = .297) and DBP (p = .167) were not significant. The interaction on HR reactivity fell short of significance, $F(1,79) = 3.35$, $p = .071$, $\eta^2 = .041$, 95% CI [-0.49, 11.62]. However, corresponding to the effects on PEP reactivity, focused cell contrasts revealed for the suboptimal-prime-presentation condition significantly stronger reactivity in the sadness-prime than in the anger-prime condition, $t(79) = 1.96$, $p = .027$, $\eta^2 = .027$, 95% CI [0.63, infinity], (1-tailed). These conditions did not significantly differ in the optimal-prime-presentation condition (p = .534).

Task Performance

A 2 × 2 ANOVA of response accuracy during the 5 minutes of task performance revealed a Visibility main effect ($p = .041$, $\eta^2 = 0.05$, 95% CI [0.01, 0.03]), qualified by a significant interaction, $F(1,79) = 5.68$, $p = .020$, $\eta^2 = .07$, 95% CI [0.01, 0.07]. As depicted in Figure 2, the cell mean pattern corresponded to that of PEP reactivity at the beginning of the task: In the suboptimal-prime-presentation condition, accuracy in the sadness-prime cell (M = 96.52%, SE = 0.57) was significantly higher than in the anger-prime cell (M = 93.75%, SE = 1.18), $t(79) = 2.53$, $p = .014$, $\eta^2 = .08$, 95% CI [0.01, 0.05]. No significant difference emerged in the optimal-prime-presentation condition (sadness-prime: M = 96.29%, SE = 0.61; anger-prime: M = 97.19%, SE = 0.62; p = .407). There was no significant time effect on accuracy (p = .658).

For reaction times of correct responses in milliseconds, the pattern of cell means was opposite to that of response accuracy, suggesting that there was no speed-accuracy tradeoff. In the suboptimal-prime-presentation condition, responses in the sadness-prime cell were faster (M = 742.48, SE = 33.67) than in the anger-prime cell (M = 789.32, SE =

33.23). The opposite pattern emerged in the optimal-prime-presentation condition, where responses in the anger-prime condition (*M* = 712.58, *SE* = 19.94) were faster than in the sadness-prime cell (*M* = 760.57, *SE* = 32.77). However, a 2 x 2 ANOVA found no significant interaction (p = .123) or main effect (*p*s > .338).

Experienced Affect

We created sadness and anger sum scores for the pre-task (*r*s ≥ .41, *p*s < .001) and post-task (*r*s ≥ .34, *p*s < .002) measures. A 2 (Prime) x 2 (Visibility) x 2 (Time) mixed-model ANOVA of the sadness scores revealed significant Time, $F(1,78) = 18.88$, $p < .001$, $\eta^2 = .20$, 95% CI [0.34, 0.93], and Prime, $F(1,78) = 5.61$, $p = .02$, $\eta^2 = .05$, 95% CI [0.21, 2.37], main effects, reflecting lower sadness after (*M* = 2.72, *SE* = 0.12) than before the task (*M* = 3.37, *SE* = 0.18) and higher sadness in the anger-prime (*M* = 3.37, *SE* = 0.20) than in the sadness-prime condition (*M* = 2.73, *SE* = 0.19). A 2 x 2 x 2 ANOVA of the anger scores only yielded a significant Time main effect, $F(1,78) = 4.13$, $p = .045$, $\eta^2 = .05$, 95% CI [0.01, 0.45], reflecting higher anger before (*M* = 2.67, *SE* = 0.15) than after the task (*M* = 2.44, *SE* = 0.11).

Most relevant, additional ANCOVAs found no significant associations between mood scores and PEP reactivity (*p*s ≥ .95). These findings do not lend any support to the possibility that the affect primes elicited prime-congruent conscious feelings and thus PEP reactivity.

Task Ratings

No significant effects emerged on the difficulty ratings (*p*s > .285). However, a 2 x 2 ANOVA of the success importance ratings revealed a significant Prime main effect, $F(1,79) = 4.59$, $p = 0.035$, $\eta^2 = 0.06$, 95% CI [0.04, 1.06]), and a significant interaction, $F(1,79) = 5.42$, $p = 0.022$, $\eta^2 = 0.06$, 95% CI [0.17, 2.22]. In the suboptimal condition, success importance in the sadness-prime cell (*M* = 6.00, *SE* = 0.18) was rated higher than in the anger-prime cell (*M* = 4.85, *SE* = 0.38), $t(79) = -3.14$, $p = 0.002$, $\eta^2 = 0.11$, 95% CI [0.42, 1.88]. No significant difference emerged in the optimal condition (sadness-primes: *M* = 5.81, *SE* = 0.24; anger-primes: *M* = 5.86, *SE* = 0.20; *p* = 0.896). The Visibility main effect was not significant (*p* = 0.116).

Funnel Debriefing

No participant correctly guessed the study' purpose. When asked to describe a trial, only 9.5% (4 participants) reported to have seen emotional faces in the suboptimal-prime-presentation condition, whereas 90.5% (38 participants) did so in the optimal condition.

Discussion

As expected, prime visibility was a boundary condition of automatic effort mobilization during cognitive processing. Suboptimally presented sadness primes led to stronger effort-related cardiac response in terms of PEP reactivity than suboptimally presented anger primes. Most relevant, these effects, which replicate previous findings in the context of the IAPE model (e.g., Chatelain & Gendolla, 2015; Gendolla & Silvestrini, 2011), were moderated and diminished when the primes were clearly visible.

In a broader perspective, the present findings fit recent ideas about the conditions of automaticity (Loersch & Payne, 2011; Wheeler, DeMarree, & Petty, 2007). Accordingly, the mental content that is activated by prime exposure is more likely to have an effect when it can be attributed to the self than when it is ascribed to an external influence. That is, automaticity should only work if individuals are unaware of being primed. By contrast, when participants suspect primes to bias their judgments and behavior, they should respond to this contamination with behavior correction (Martin, 1986; Martin, Seta, & Crelia, 1990; Mussweiler & Neumann, 2000). Thus, conscious awareness of affect primes that have nothing to do with a task should induce suspicion and thus motivate them to correct their behavior (Gendolla, 2015): If people prefer autonomy (Ryan & Deci, 2000) and think that they act in accordance with their own decisions (Loersch & Payne, 2012), they should dislike being manipulated and react to perceived external influences (Brehm, 1966). Accordingly, also participants in the optimal-prime-presentation condition should have felt an impulse to mobilize more effort in the sadness-prime condition and less effort in the anger-prime condition, because sadness is associated with ease and anger is associated with difficulty (e.g., Gendolla & Silvestrini, 2011). But making a link between that impulse and the facial expressions that surprisingly appeared during the main task should have resulted in behavior correction in order to re-establish freedom and autonomy. Indeed, prime visibility seems to be a powerful moderator of automaticity (see also Bijleved et al., 2011; Chaillou et al., 2015; Lasauskaite Schüppbach et al., 2014; Murphy & Zajonc, 1993).

Our results are also in accordance with other studies that highlighted the awareness of knowledge activation as a moderator of priming effects on evaluative judgments (e.g., Lombardi, Higgins, & Bargh, 1987; Murphy & Zajonc, 1993; Rotteveel, Groot, Geutskens, & Phaf, 2001; Strack, Schwarz, Bless, Kübler, & Wänke, 1993) and decision-making (e.g., Verwijmeren, Karremans, Bernritter, Stroebe, & Wigboldus, 2013; Loersch & Payne, 2012). Moreover, the visibility of threatening stimuli can moderate their effects on cerebral responses (Carlsson et al., 2004) and fearful reactions (Siegel & Warren, 2013; Siegel & Weinberger, 2012). Most relevant, prime awareness was also found to be a powerful moderator of affect prime effects in the context of effort mobilization (Lausauskaite Schüpbach et al., 2014; Chaillou et al., 2015). However, those studies compared affect primes of positive vs. negative valence and left it open if the affect prime effects and their moderation by visibility were emotion-specific or valence-specific. The present study found effects for primes of two negative emotions and speak for the emotion-specific effect predicted by the IAPE model (Gendolla, 2012, 2015).

The present performance data highlighted a significant affect prime x visibility interaction effect on response accuracy. Participants responded more accurately when they implicitly processed sadness primes than when they were exposed to suboptimally presented anger primes. When the primes were clearly visible, this effect disappeared. Some researchers consider speed and accuracy as indicators of effort (e.g., Bijleveld, Custers, & Arts, 2010) and some of our previous studies also revealed performance effects that corresponded to effort-related cardiovascular response (e.g., Gendolla & Silvestrini, 2010, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2013). However, it is of note that *performance* effects are not in the focus of the IAPE model, which explains and predicts how implicitly processed affective stimuli influence *effort mobilization*. Effort (a behavioral input variable) and performance (a behavioral output variable) are not interchangeable concepts. Beside effort, performance depends—at least—on ability and strategy use (Locke & Latham, 1990). This may explain why performance effects occurred for the entire task performance period while effects on PEP response were limited to the beginning of task performance. The link between effort and performance is complex and calls for further investigation. In contrast to response accuracy, effects on response speed were not significant in the present study, which is not surprising given that the task instructions asked participants to respond correctly and fast, putting an accent on accuracy. Most relevant, the pattern of response times across the conditions does not support the possibility that there was a speed-accuracy tradeoff and that higher accuracy occurred because of slower responses.

Among our cardiovascular measures only PEP reactivity showed the significant two-way interaction effect of affect primes and prime visibility. This is in line with the idea that PEP is the most sensitive noninvasive index of beta-adrenergic sympathetic impact on the heart (Kelsey, 2012). The other cardiovascular indices showed patterns that largely corresponded with those of PEP, and especially the interaction effect on HR fell only short of significance. Most relevant, PEP effects were not accompanied by decreases in blood pressure or HR, meaning that cardiac contractility could not be explained by pre- or afterload effects (see Sherwood et al., 1990).

Regarding subjective measures, participants' difficulty ratings assessed after the task did not show any significant effects. However, the IAPE model is concerned with implicit effects on task demand *during* performance, rather thereafter. Moreover, it is possible that demand was only influenced on the implicit level, i.e. without awareness (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009), making it inaccessible for self-report, and calling for implicit measures of links between affect primes and the ease- and difficulty concepts (e.g., Lasauskaite, Gendolla, Bulmont, & Freydefont, 2017). By contrast, we found a significant interaction effect on participants' success importance ratings that corresponded to the effect on PEP—our primary effort measure. This effect has not been observed before. In the previous research by Gendolla and Silvestrini (2011), sadness primes resulted in higher ratings of subjective task difficulty and equal ratings of success importance than anger primes. The present effect on rated success importance may be explicable as actually reflecting effort effects on subjective goal value, as predicted by motivational intensity theory (Brehm, Wright, Solomon, Silka, & Greenberg, 1983), and recently rediscovered by others (e.g., Higgins, 2006). Accordingly, the value of success is a direct function of the effort individuals mobilize for succeeding.

As a final point, it is noteworthy that our affect measures did not reveal any prime-congruent effects on reported feelings that could alternatively explain the observed PEP effects in terms of induced emotional states—which is consistent with previous studies (Freydefont & Gendolla, 2012; Freydefont, Gendolla, & Silvestrini, 2012; Gendolla &

Silvestrini 2011; Lasauskaite et al. 2013; Silvestrini & Gendolla 2011a,c). In this context it is also important to note that we did not find significant effects on blood pressure—which are typical for anger (see Kreibig, 2010), especially for anger elicitation during task performance (e.g., Bongard, Pfeiffer, Al'Absi, Hodapp, & Linnenkemper, 1997).

In summary, we interpret the present findings as additional evidence for the systematic effect of implicitly processed affective stimuli on effort mobilization during cognitive processing and, most importantly, that prime visibility is a moderator variable in this process: Prime visibility is a boundary condition of effort automaticity.

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Footnotes

[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.

[2] Because of the relatively small number of men in the sample we did not include Gender as a factor in the analysis. However, the results are basically the same if we restrict the data analysis to women.

[3] One-tailed test due to the directed hypothesis in the suboptimal condition.

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Table 1

Means and standard errors (in parentheses) of the cardiovascular baseline values.

	Suboptimal		Optimal	
	Sadness Primes	Anger Primes	Sadness Primes	Anger Primes
PEP	100.94 (1.87)	100.29 (2.31)	101.49 (1.61)	97.60 (2.54)
SBP	102.47 (2.48)	102.77 (1.80)	103.21 (2.12)	102.71 (1.41)
DBP	60.40 (1.52)	58.18 (1.05)	59.48 (1.44)	59.83 (1.13)
HR	78.27 (2.28)	75.12 (3.00)	78.19 (1.89)	80.24 (2.57)

Note: PEP = pre-ejection period (in ms), SBP = systolic blood pressure (in mmHg), DBP = diastolic blood pressure (in mmHg), HR = heart rate (in beats/min).

Table 2

Means and standard errors (in parentheses) of systolic blood pressure, diastolic blood pressure and heart rate reactivity during task performance.

	Suboptimal		Optimal	
	Sadness Primes	Anger Primes	Sadness Primes	Anger Primes
SBP	8.58 (1.54)	5.73 (1.20)	6.51 (1.09)	6.77 (1.93)
DBP	5.90 (0.97)	4.43 (0.89)	2.81 (0.81)	3.93 (1.04)
HR	6.78 (2.22)	2.13 (1.33)	0.9 (0.96)	2.24 (1.36)

Note: DBP = diastolic blood pressure (in mmHg), HR = heart rate (in beats/min).

Figure Captions

Figure 1. Cell means and ±1 standard errors of cardiac pre-ejection period reactivity (in ms) during the first minute of task performance.

Figure 2. Cell means and ±1 standard errors of accuracy in % of correct response during task performance.

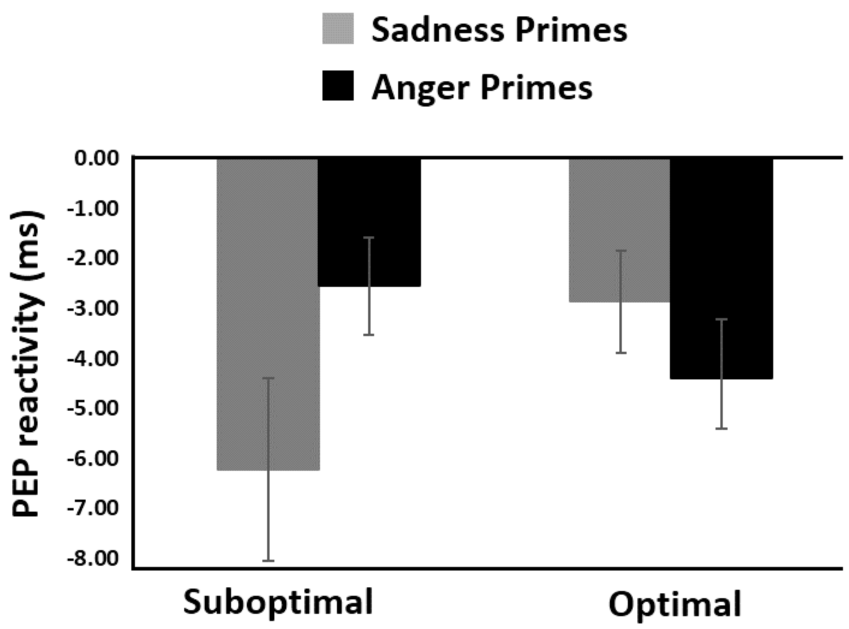

Figure 1

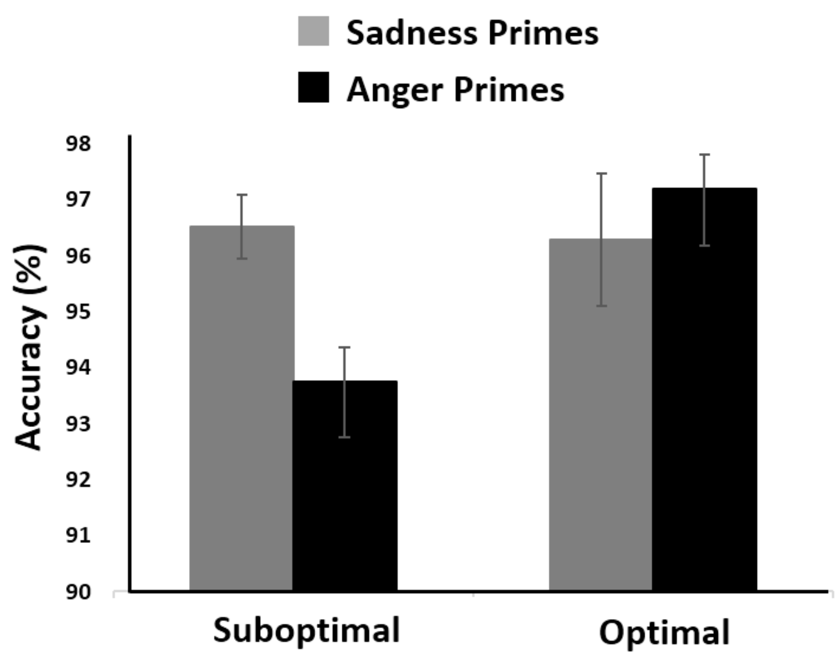

Figure 2