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Running Head: Prime Warning and Effort

Prime Warning Moderates Implicit Affect Primes' Effect on Effort-Related Cardiac Response in Men

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Abstract

Based on the Implicit-Affect-Primes-Effort model (Gendolla, 2012, 2015), we tested whether warning individuals about the occurrence of affect primes during a cognitive task moderates the primes' effect on effort-related cardiac response. Participants worked on a challenging mental arithmetic task with integrated masked affect primes—very briefly flashed pictures of facial sadness vs. happiness expressions. Additionally, half of the participants were warned about the primes' appearance and their possible effect on experienced task demand; the other half of the participants was not informed about the primes. Reactivity of cardiac pre-ejection period (PEP) was stronger in the happiness-prime than in the sadness-prime condition, but only when the participants were not warned about the primes' presence. This effect was further moderated by gender and only significant among men. Heart rate (HR) responses showed a largely corresponding effect. The results suggest that prime-warning is a boundary condition of implicit affects' effect on effort mobilization—and that this effect applies especially to men.

Keywords: Implicit Affect; Effort; Cardiovascular; Automaticity; Prime Awareness

Introduction

Research on the Implicit-Affect-Primes-Effort (IAPE) model (Gendolla, 2012) has revealed ample evidence for the systematic impact of implicitly processed affective stimuli on effort-related cardiovascular responses in cognitive tasks. To better understand the conditions that facilitate or impede automaticity in behavior, we investigated the role of prime awareness as a possible boundary condition of this effect.

The IAPE model posits that individuals learn that performing tasks is easier in some affective states than in others. That way, performance ease and difficulty become features of different affective states' mental representations. More specifically, happiness and anger become associated with ease (both are characterized by high coping potential), whereas sadness and fear become associated with difficulty (both are characterized by low coping potential; see Lerner & Keltner, 2001; Scherer, 1993; Smith & Lazarus, 1990). That is, ease and difficulty become features of different emotion's mental representations. Affective stimuli that are implicitly processed during a task should render the ease or difficulty concepts accessible, resulting in lower or higher experiences of task demand during performance. Effort-related physiological responses should then follow the principles of motivational intensity theory (Brehm & Self, 1989): effort should rise proportionally with subjective demand as long as success is possible and justified.

Several experiments found support for the predictions of the IAPE model. When people worked on relatively easy tasks, implicit processing of sadness or fear primes led to stronger effort-related cardiovascular responses than processing happiness or anger primes (e.g., Chatelain & Gendolla, 2015; Gendolla & Silvestrini, 2011; Lasauskaite, Gendolla, & Silvestrini, 2013). Importantly, these simple affect prime effects were inversed in objectively difficult tasks. Here, happiness or anger primes led to stronger cardiovascular reactivity than

sadness or fear primes (e.g., Chatelain, Silvestrini & Gendolla, 2016; Freydefont, Gendolla, & Silvestrini, 2012; Silvestrini & Gendolla, 2011a; see also Blanchfield, Hardy, & Marcora, 2014; Silvestrini, 2018). The reason is that happiness and anger primes result in high but feasible subjective demand in difficult tasks, while sadness and fear primes lead to very high subjective demand and thus disengagement. However, if people who were implicitly primed with sadness or fear expect high incentive for succeeding on difficult tasks, they showed very high cardiovascular responses, because high incentive justifies the subjectively necessary very high effort (Chatelain & Gendolla, 2016; Freydefont & Gendolla, 2012; see also Silvestrini, 2015; Zafeiriou & Gendolla, 2017).

In summary, there is replicated evidence for implicit affect's systematic impact on effort-related cardiovascular responses and its moderation by two task context variables: objective task difficulty and performance-contingent incentive. However, all of these effects were observed when affect primes were implicitly processed. Thus, the question arises what happens when individuals become aware of being primed. Or in other, more general terms: is prime awareness a boundary condition of automatic effort mobilization?

Prime Awareness Effects

Recent research suggests that priming influences on behavior only occur if people are unaware of primes' presence or effects. Prime visibility has been found to be a boundary condition of automaticity: compared with masked affect primes, clearly visible primes either lost their effects (Chaillou, Giersch, Bonnefond, Custers, & Capa, 2015; Framorando & Gendolla, 2018a) or even led to inverted (i.e. contrast) effects on resource mobilization measures (Framorando & Gendolla, 2018b; Lasauskaite Schüpbach, Gendolla, & Silvestrini, 2014). Similarly, 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). This

suggests that the automatic processes that are activated by implicit priming are interrupted and modified when people become aware of being primed.

According to Loersch and Payne (2012), priming can only be effective if people misattribute their prime-related mental content to their own thoughts. Under this condition, people assimilate the thoughts that are actually activated by a priming procedure to their self. This is not possible if one is aware of the external source of their mental content—the priming procedure. To further explain why primes loose their effect under the condition of prime awareness, Gendolla (2015) suggested that the underlying processes should be behavior correction. This is based on the idea that people should prefer autonomy (Ryan & Deci, 2000) and think to act in accordance with their own thoughts and decisions (Loersch & Payne, 2012). Considering this, people should dislike perceived external influences—like priming procedures they become aware of—and should show reactance in order to re-establish freedom and autonomy (Brehm, 1966). Following this logic, the present experiment tested whether prime awareness, manipulated by warning participants of the appearance and effect of briefly flashed masked affect primes during a cognitive task, should be a boundary condition of automatic effort mobilization. Prime warning should induce awareness of the priming procedure—participants know that primes are present even if they cannot see them—which should render a misattribution of the prime-related mental content to participants' self difficult (e.g., Oikawa, Aarts, & Oikawa, 2011) and promote behavior correction (Gendolla, 2015).

Effort-Related Cardiovascular Response

According to Wright's (1996) integration of motivational intensity theory (Brehm & Self, 1989) with the active coping approach (Obrist, 1981), effort is reflected by beta-adrenergic sympathetic nervous system impact on the heart. Beta-adrenergic activity is manifested in increased cardiac contractility and thus shortened cardiac 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). Supporting this reasoning, PEP has been found to sensitively respond to manipulations of task demand (Richter, Friedrich, & Gendolla, 2008), incentive (Richter & Gendolla, 2009), and combination of both (Silvestrini & Gendolla, 2011c).

Due to its systematic link with cardiac contractility, several studies have also assessed systolic blood pressure (SBP) to monitor effort (see Wright & Kirby, 2001; Gendolla, Wright, & Richter, 2012; Richter, Gendolla, & Wright, 2016 for reviews). However, SBP—and to an even stronger degree diastolic blood pressure (DBP)—is also influenced by peripheral vascular resistance, which is not systematically influenced by beta-adrenergic activation (Levick, 2003). Still other studies relied on heart rate (HR) as indicator of effort (e.g., Elliott, 1969; Eubanks, Wright, & Williams, 2002). However, HR can increase because of both sympathetic activation and parasympathetic deactivation (Berntson, Cacioppo, & Quigley, 1993), making it difficult to predict effort-related HR changes. That is, changes in PEP during task performance provide the most sensitive and reliable index of effort among these indicators (Kelsey, 2012). Nevertheless, PEP should always be assessed together with HR and blood pressure to control for possible preload (ventricular filling) or afterload (arterial pressure) effects on PEP (Sherwood et al., 1990).

The Present Study

Participants worked on a relatively challenging arithmetic task in which they were exposed to masked sadness vs. happiness primes. To test whether the awareness of being primed is a boundary condition of implicit affect's impact on effort-related cardiovascular response, we warned half the participants that affective stimuli would be presented during the task, which could influence their experiences of task demand. We expected a Prime x Warning interaction effect with an affect prime effect on effort-related cardiovascular

response, especially PEP, in the no-warning condition. This effect should be moderated by the prime-warning manipulation. Here, due to behavior correction, the prime effect should either be attenuated (e.g., Chaillou et al., 2015; Verwijmeren et al., 2013; Framorando & Gendolla, 2018a), or even turn into a prime-contrast effect in the case of overcorrection (e.g., Framorando & Gendolla, 2018b; Lasauskaite Schüpbach et al., 2014). In any case, we expected that prime-warning should moderate the effect of the affect primes.

In addition to the primary goal of testing whether prime-warning is a boundary condition of implicit affects' impact on effort mobilization, this study controlled for the possible role of gender. Most of our previous studies were conducted with psychology students. Consequently, the investigated samples were predominantly female, reflecting the gender distribution in that population. Those studies did not permit conclusive tests of gender effects and one could argue that the documented effort effects of implicit affect may be limited to women—or even women studying psychology. Moreover, one recent study found that gender significantly moderated the effect of prime visibility on effort-related cardiac response (Framorando & Gendolla, 2018b): visible primes resulted in a prime contrast effect among men, but not among women. This calls for further tests of the role of gender. Therefore, we recruited university students from various study domains in a larger sample that permitted conclusive tests of the possible role of gender as a moderator of implicit affects' impact on effort-related cardiovascular response.

Method

Participants and Design

To comply with the principle to collect valid data of at least 20 participants per between-persons condition (Simmons, Nelson, & Simonsohn, 2011), we randomly assigned 170 university students to the experimental conditions of our 2 (Prime) x 2 (Warning) x 2 (Gender) between-persons design. 4 of these participants were removed from the analysis: 1

suffered from an Attention Deficit Hyperactivity Disorder syndrome, 1 had an extremely low response accuracy (13%) in the arithmetic task, 1 suffered from a heavy cold, and 1 showed excessively strong PEP reactivity during the task (> 3 *SD*s than both the condition and grant means) and was considered an outlier. This left a final sample of $N = 166$ (81 women, average age 23.30 years; 85 men, average age 23.66).

Affect Primes

Pictures from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998) showing low frequency averaged neutral (MNES, FNES), sad (MSAS, FSAS), and happy (MHAS, FHAS), front perspective faces were used as affect primes. The pictures were in grey-scale. Half of them were averaged female faces and half were averaged male faces.

Apparatus and Physiological Measures

Impedance cardiogram (ICG) and electrocardiogram (ECG) signals were noninvasively assessed (sample rate 1,000 Hz) with a Cardioscreen 1000 system (medis, Ilmenau, Germany; see Scherhag, Kaden, Kentschke, Sueselbeck, & Borggrefe, 2005, for a validation study) to monitor HR and PEP. Four pairs of electrodes (Ag/AgCl, Medis, Ilmenau, Germany) were placed on the left and right sides of participants' neck and chest. The signals were amplified, digitalized with a sampling rate of 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; see Reinders, Reggiori, & Shennan, 2006 for a validation study). The blood pressure cuff was placed over the brachial artery above the elbow of participant's non-dominant arm. For readers who are interested in a fuller picture of hemodynamic responses, which were not related to our hypotheses, we also assessed cardiac output and total peripheral resistance (see Supplementary Material).

Procedure

The experimental procedure had been approved by the local ethics committee. The experimenter was hired and unaware of both the hypotheses and the experimental conditions. Participants were seated in a comfortable chair in front of a 120 Hz computer screen, gave signed consent, and were equipped with the physiological sensors. Then the experimenter started the computer program running the experiment (E-Prime, Psychology Software Tools, Pittsburgh, PA) and went to an adjacent control room. The program started with biographical questions (age, gender, etc.) and ratings of participants' affective state before the exposure to the affect primes (2 sadness items: down, sad; 2 happiness items: happy, joyful) on 7-point scales (1—*not at all*, 7—*very much*). To prevent suspicion, the affect measures were introduced as standard assessment because people enter the laboratory in different feeling states. Next, participants watched a hedonically neutral documentary film about Portugal (8 min) to assess cardiovascular baseline values. This was followed by a challenging arithmetic task (5 min) adapted from (Bijleveld, Custers, & Aarts, 2010) during which we assessed performance-related cardiovascular activity.

In order to have equal gender distributions in each condition, we randomly assigned men and women separately to the experimental conditions (see Table 1). For participants in the prime-warning condition, the task was preceded by a screen informing them that pictures of emotional expressions would be embedded in the arithmetic task and that those could have

an influence on subjective task difficulty: "*We inform you that pictures of sad faces* (or happy faces, respectively, in the happiness-prime condition) *will be presented in this task. Previous research has shown that these faces could influence the perceived difficulty of the task.*" Participants in the no-warning condition did not receive this message.

Each of the 30 trials of the arithmetic task consisted of a fixation cross (1000 ms), followed by a briefly flashed face picture (affect prime) that centrally appeared for 25 ms, followed by a grey random dot picture mask (133 ms). Emotional (sad vs. happy) faces were presented in 1/3 of the trials (neutral faces were presented in the other trials) to prevent prime-habituation effects (Silvestrini & Gendolla, 2011b). The mask was followed by a second fixation cross (1000 ms) and an arithmetic equation, consisting of 3 added up single digits and a two-digit result. (e.g., 3 + 9 + 8 = 18). The equations appeared for 5000 ms during which participants had to decide whether the presented result was correct or not by pressing a "yes" or a "no" key with the index and middle fingers of their dominant hand. Participants were instructed to try to respond correctly and as fast as possible. Half of the presented equations were correct, half were incorrect. To keep the task challenging, the incorrect equations presented results that differed by maximally 2 digits from the correct results. The inter-trial interval lasted from 1000 to 2000 ms. Before the main task, participants performed 8 practice trials in which they received correctness feedback. To avoid possible affective reactions (Kreibig, Gendolla, & Scherer, 2012) that could interfere with the affect primes' impact, no correctness feedback was given during the task. Participants only received the feedback "Response entered". This message appeared for 6500 ms minus participants' reaction time so that each participant worked for the same time. In both the practice and the task trials, the feedback "Please respond faster" was displayed for 1500 ms if participants did not respond within the response time window.

After the task, participants rated the same affect items as at the procedure's onset, task difficulty, their subjective math capability, in how far they liked mental calculations (in order to control for subjective ability differences in mathematics, which could influence effort mobilization, Wright, 1998), and success importance on scales ranging from 1 (*not at all*) to 7 (*very much*). Moreover, they indicated eventual medication. Finally, participants were asked in a funnel debriefing to guess the study's purpose and to describe a trial of the arithmetic task. Those who mentioned flickers were asked to describe their content.

Results

Cardiovascular Baselines

As usual for determining stable cardiovascular baseline values, we ran repeated-measures ANOVAs of the eight 1-min scores of PEP, HR, SBP, and DBP to test for time effects during habituation. Theses analyses revealed significant Time main effects, *Fs*(7, 1155) > 5.83, *ps* < .001, $\eta^2 > .03$, due to higher cardiovascular activity at the beginning of the habituation period. The cardiovascular baselines were hence calculated by averaging the last three 1-min scores of the habituation period, which did not differ significantly according to Tukey HSD tests (*p*s > .20) and proved high internal consistency (Cronbach's αs > .95). Cell means and standard errors appear in Table 1. Two (Prime) x 2 (Warning) x 2 (Gender) ANOVAs found significant gender main effects on both the SBP, $F(1, 158) = 24.93$, $p < .001$, $\eta^2 = .14$, and the HR baselines, $F(1, 158) = 4.42$, $p = .037$, $\eta^2 = .03$. Men had higher SBP baseline values ($M = 106.81$, $SE = 1.02$) than women ($M = 99.56$, $SE = 1.05$), which is usual (Wolf et al., 1997). Conversely, women had higher HR baseline values ($M = 74.70$, $SE = 1.33$) than men ($M = 71.10$, $SE = 1.05$). Additionally, there was a significant three-way interaction on the PEP baselines, $F(1, 158) = 5.39$, $p = .022$, $\eta^2 = .03$. To decompose this interaction, we ran separate 2 (Prime) x 2 (Visibility) ANOVAs for men and women.

However, neither ANOVA revealed any significant effects (*ps* > .054). In addition, no significant effects emerged for the baselines of the other cardiovascular indices (*p*s > .096).

Cardiovascular Reactivity

We averaged the five 1-min scores of PEP, HR, SBP, and DBP assessed during task performance (Cronbach's αs ≥ .88) and subtracted the baseline values from them to create cardiovascular reactivity scores.

PEP Reactivity

A 2 (Prime) × 2 (Warning) x 2 (Gender) between-persons ANOVA revealed a significant Prime main effect, $F(1, 158) = 7.89$, $p = .006$, $\eta^2 = .05$, 95% CI [2.097 ; 12.021], due to stronger PEP reactivity in the happiness-prime ($M = -3.47$, $SE = 0.54$) than in the sadness-prime condition ($M = -1.70$, $SE = 0.36$). As expected, this main effect was moderated by the Warning manipulation, as evident in a significant two-way interaction effect, $F(1, 158) = 3.98$, $p = .048$, $\eta^2 = .03$, 95% CI [0.050 ; 9.973]. As depicted in Figure 1 and supported by focused contrasts, participants in the no-warning condition who were primed with happiness showed significantly stronger PEP reactivity ($M = -4.60$, $SE = 0.88$) than those who were primed with sadness ($M = -1.52$, $SE = 0.50$), $t(158) = 3.40$, $p < .001$, $\eta^2 = .07$, 95% CI [2.524; 9.546]—which is the typical effect of happiness and sadness primes that are implicitly processed during a demanding task (e.g., Lasauskaite Schüpbach et al., 2014; Silvestrini & Gendolla, 2011a). Conversely, in the warning condition, the happiness-prime ($M = -2.37$, $SE = 0.59$) and sadness-prime conditions ($M = -1.89$, $SE = 0.51$) did not differ ($p = .565$), 95% CI [-4.530; 2.483]. That is, prime-warning moderated, as expected, the effect of the affect primes. This supports our major hypothesis about prime-warning as a boundary condition of implicit affects' effect on effort-related cardiac response.

However, additionally, the Prime x Warning x Gender interaction was significant, $F(1, 158) = 4.59$, $p = .034$, $\eta^2 = .03$, 95% CI [0.419; 10.343]. Cell means and standard errors are

depicted in Figure 2. To decompose this interaction, we ran focused crossover interaction contrasts which revealed a significant Prime x Warning interaction for men, $F(1, 158) = 8.77$, $p = .004$, $\eta^2 = .05$, 95% CI [1.731 ; 8.661], but not for women ($p = .918$), 95% CI [-3.367; 3.736]. Additional cell contrasts for men revealed that the happiness primes ($M = -5.71$, $SE = 1.41$) produced stronger PEP responses, $t(158) = 3.39$, $p < .001$, $\eta^2 = .07$, 95% CI [1.742; 6.613], than the sadness primes ($M = -1.54$, $SE = 0.67$) in the no-warning condition. By contrast the prime effect was not significant ($p = .415$), 95% CI [-1.446; 3.483] in the warning condition (happiness: $M = -1.13$, $SE = 0.64$; sadness: $M = -2.15$, $SE = 0.78$). Moreover, as visible in Figure 2, among women only the prime main-effect was significant, $F(1, 158) = 4.70$, $p = .032$, $\eta^2 = .04$, 95% CI [0.348 ; 7.452], reflecting stronger PEP response in the happiness-prime condition ($M = -3.52$, $SE = 0.68$) than in the sadness-prime condition ($M = -1.57$, $SE = 0.51$). Accordingly, prime warning was a boundary condition of implicit affect's impact on PEP reactivity for men, but not for women.

HR Reactivity

Cell means and standard errors of HR reactivity are depicted in Figure 3. The ANOVA found a Prime x Warning x Gender interaction $F(1, 158) = 8.77$, $p = .004$, $\eta^2 = .05$, 95% CI [2.172; 10.877] in absence of any other significant effects ($ps \geq .191$). Corresponding to the above reported effects on PEP, focused crossover interaction contrasts revealed a significant Prime x Warning interaction for men, $F(1, 158) = 9.36$, $p = .002$, $\eta^2 = .06$, 95% CI [1.668 ; 7.747], but not for women ($p = .251$), 95% CI [-4.932; 1.299]. For men, cell contrasts found in the no-warning condition a marginally significantly stronger HR response, $t(158) = 1.82$, $p = .070$, $\eta^2 = .02$, 95% CI [-0.164; 4.109], in the happiness-prime condition ($M = 3.71$, $SE = 0.73$) than in the sadness-prime condition ($M = 1.74$, $SE = 0.70$). Conversely, in the warning condition, the cell contrast, $t(158) = 2.50$, $p = .013$, $\eta^2 = .04$, 95% CI [0.574; 4.897], revealed stronger HR reactivity in the sadness-prime condition ($M = 3.90$, $SE = 1.16$) than in the

happiness-prime condition (*M* = 1.17, *SE* = 0.64). Among women, no significant effects emerged (*ps* > .431).

Blood Pressure Reactivity

Blood pressure cell means and standard errors appear in Table 2. No significant effects were found on SBP and DBP responses (*ps* > 0.19).

Experienced Affect

We created mean sadness and happiness scores for the pre-task (*r*s > .41, *p*s < .001) and post-task (*r*s > .34, *p*s < .001) affect measures. A 2 (Prime) x 2 (Warning) x 2 (Gender) x 2 (Time) mixed-model ANOVA of the sadness scores did not reveal any significant effects (*ps* > .10; average *M* = 4.67; *SE* = 09). The ANOVA of the happiness scores yielded a significant Time main effect, $F(1, 158) = 3.90$, $p = .050$, $\eta^2 = .02$, 95% CI [-0.291, 0.001], reflecting slightly higher happiness before (*M* = 4.74, *SE* = 0.09) than after the task (*M* = 4.60, *SE* = 0.09). Moreover, there was a significant Gender x Time interaction, $F(1, 158) = 7.25$, $p = .008$, $\eta^2 = .04$, CI [0.106, 0.689]. According to HSD post-hoc tests, only women rated their happiness to be higher ($p = .005$) before (*M* = 4.72, *SE* = 0.13) than after (*M* = 4.37, *SE* = 0.13) the task. This time effect was not significant for men ($p = .956$). In summary, these findings do not lend any support to the possibility that the affect primes induced conscious feelings.

Task Ratings

The 2 (Affect Prime) × 2 (Warning) x 2 (Gender) ANOVAs of the task ratings revealed some unexpected effects. The ANOVA of the success importance ratings revealed significant main effects of Warning, $F(1, 158) = 5.40$, $p = .021$, $\eta^2 = .03$, 95% CI [0.066; 0.812], and Gender, $F(1, 158) = 6.04$, $p = .015$, $\eta^2 = .04$, 95% CI [0.091; 0.837]. Participants in the no-warning condition (*M* = 5.88, *SE* = 0.13), rated the importance of success as slightly higher than those in the warning condition (*M* = 5.42, *SE* = 0.14). Men (*M* = 5.88, *SE* = 0.12)

rated the importance of success as higher than women (M = 5.41, SE = 0.15). Additionally, the Prime x Warning interaction was significant, $F(1, 158) = 4.72$, $p = .031$, $\eta^2 = .03$, 95% CI [0.075; 1.567]. According to a HSD post-hoc test, success importance in the no-warning condition (M = 6.00, SE = 0.16) was rated higher ($p = .006$) than in the warning condition (M = 5.14, SE = 0.20) when participants were primed with sadness. No other ANOVA effect was significant ($ps \geq .304$).

Participants' rating of their subjective capacity in mathematics, the degree to which they liked mental calculations, and the reverse-coded difficulty of the task were highly correlated (Cronbach's $\alpha = .82$). Therefore, we created and analyzed a mean arithmetic ability score of the three items.[1]Task difficulty ratings of one participant were missing. As for the success importance ratings, a 2 (Prime) x 2 (Warning) x 2 (Gender) ANOVA revealed a significant Warning main effect, $F(1, 157) = 10.64$, $p = .001$, $\eta^2 = .06$, 95% CI [0.247; 1.004], due to higher subjective ability in the no-warning condition (M = 4.85, SE = 0.14) than in the warning condition (M = 4.23, SE = 0.14). Additionally, the main effect of Gender was significant, $F(1, 157) = 26.32$, $p < .001$, $\eta^2 = .14$, 95% CI [0.605; 1.363]. Men (M = 5.02, SE = 0.13) rated their ability as higher than women (M = 4.03, SE = 0.15). No other effect was significant ($ps > .211$).

Task Performance

Two (Affect Prime) × 2 (Warning) x 2 (Gender) ANOVAs for reaction times (in ms) and response accuracy (% of correct responses) during the 5 min of task performance revealed gender main effects for both reaction times, $F(1, 158) = 6.84$, $p = .010$, $\eta^2 = .04$, 95% CI [38.326; 274.47] and response accuracy, $F(1, 158) = 6.55$, $p = .011$, $\eta^2 = .04$, 95% CI [1.090; 8.455]. Men respond faster (M = 2591.13, SE = 43.70) and more accurately (M = 88.76%, SE = 1.22) than women (reaction times: M = 2747.01, SE = 39.65; accuracy: M = 83.91%; SE = 1.40). [DF1]No other effect was significant ($ps > .136$[MOU2][DF3]).

Funnel Debriefing

In the funnel debriefing, no participant correctly guessed the purpose of the study. When asked to describe a trial, only 18 participants (21.7%) reported to have seen an emotional face in the no-warning condition, whereas 48 participants (57.8%) did so in the warning condition.

Discussion

This study provides the first evidence for the role of prime warning as a boundary condition of implicit affect's impact on effort-related cardiac response—and suggests that this applies especially to men. Happiness- and sadness- primes influenced PEP reactivity, as predicted by the IAPE model for a challenging cognitive task (Gendolla, 2012)—PEP responses were stronger in the happiness-prime than in the sadness-prime condition. The IAPE model predicts this because of an additive effect of objective task difficulty (challenging) and access to the ease (happiness-prime) and difficulty (sadness-prime) concepts on subjective task demand during performance. This in turn leads to higher effort mobilization in the happiness-prime condition (high but feasible demand) and low effort in the sadness-prime condition (disengagement due to excessive demand), as shown in previous research (e.g., Lasauskaite Schüpbach et al., 2014; Silvestrini & Gendolla, 2011a; see also Blanchfield et al., 2014; Chatelain et al., 2016; Freydefont et al., 2012). Most relevant, the affect-prime effect was moderated by the prime-warning manipulation, as indicated by the expected significant Prime x Warning interaction—the prime effect was only significant in the no-warning condition. This suggests that the automatic processes that are normally activated by implicit priming were interrupted when participants were made aware of the priming procedure.

Prime warning should induce awareness of the priming procedure. Under such condition, it becomes difficult to misattribute the prime-related mental content to the self,

which is a prerequisite for behavior priming effects. 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. Accordingly, awareness of being primed should motivate behavior correction to restore freedom and autonomy (Brehm, 1966). This idea matches with other research that identified the awareness of external knowledge activation as a moderator of prime 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., Loersch & Payne, 2012; Verwijmeren et al., 2013). Correspondingly, prime visibility—another manipulation of prime awareness—also moderated affect prime effects on effort mobilization (Chaillou et al., 2015; Framorando & Gendolla, 2018a, 2018b; Lasauskaite Schüpbach et al., 2014). Our present findings show that warning about the appearance of masked (i.e. hardly visible) primes has corresponding effects.

As in a recent study on the role of prime visibility on effort mobilization (Framorando & Gendolla, 2018b), the predicted Prime x Warning interaction effect in the present experiment was further moderated by participants' gender: the Prime x Warning interaction was only significant among men, while women only showed a prime main effect. One could argue that this gender effect conflicts with studies by Framorando and Gendolla (2018a) and Lasauskaite Schüpbach et al. (2014), in which prime visibility significantly moderated affect primes' effect on effort mobilization in predominantly female samples. We hypothesize that these discrepancies could be explained in terms of individual differences in the need for autonomy, which is at stake for psychological reactance. There is indeed support for the idea that men are more reactant than women (e.g., Seeman, Buboltz, Jenkins, Soper, & Woller, 2004; Woller, Buboltz, & Loveland, 2007). Correspondingly, there is evidence that men resist more to external influences than women (e.g., Eagly, 1983; Maccoby, 1990). Thus, we

assume that gender differences in prime awareness effects could be due to differences in the need for autonomy, meaning that those effects should occur among women if they have a strong need for autonomy—as it was probably the case in the studies by Framorando and Gendolla (2018a) and Lasauskaite Schüpbach et al. (2014). However, this idea calls for future research highlighting the role of the need for autonomy in prime awareness effects more directly.

A significant Prime x Warning x Gender interaction effect on HR reactivity largely corresponded to that of PEP: the Prime x Warning interaction was again only significant among men. The only difference between the PEP and HR responses was that men's HR reactivity in the sadness-prime/warning condition was stronger than in the happiness-prime/warning condition, reflecting a prime contrast effect. HR responses have been previously linked with effort mobilization (e.g., Bongard, & Hodapp, 1997; Eubanks et al., 2002; Freydefont & Gendolla, 2012; Gendolla & Richter, 2005; Obrist, 1981; Zafeiriou & Gendolla, 2017, 2018). However, such effects are difficult to predict, because HR is determined by both sympathetic and parasympathetic activity. Usually, cognitive tasks only evoke small changes in HR, which are likely to rely on parasympathetic withdrawal rather than sympathetic activation. Participants in the present experiment worked on a challenging concentration task, which produced relatively strong HR changes. This might explain why HR reactivity largely corresponded to that of PEP. By contrast, no significant effects emerged on SBP and DBP reactivity. This is consistent with the fact that PEP is the most sensitive noninvasive index of beta-adrenergic sympathetic impact on the heart (see Kelsey 2012). SBP and DBP reactivity are also influenced by peripheral vascular resistance, which is not systematically influenced by beta-adrenergic activation (Levick, 2003). Most important, the PEP responses were not accompanied by decreases in HR or blood pressure, making it

implausible that PEP reactivity may have been caused by preload or afterload effects instead of a beta-adrenergic sympathetic impact on cardiac contractility (see Sherwood et al., 1990).

Regarding the self-report measures, women rated their mathematical ability as lower than men, which is consistent with other studies (Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Kiefer & Sekaquaptewa, 2007; Nosek, Banaji, & Greenwald, 2002). Additionally, there was the surprising effect that the ability ratings in the prime-warning condition were lower than in the no-warning condition. Moreover, we found that both men and participants in the warning condition rated success importance as higher than women and participants in the no-warning condition, respectively. We can only attribute these findings to chance. All task ratings were assessed retrospectively, meaning that they suffered from a number of biases that are typical for retrospective measures (see Robinson & Clore, 2002). This may also explain why affect primes in our previous studies consistently had the predicted effects on PEP reactivity but only sometimes on retrospectively assessed subjective demand (e.g., Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011a). Most relevant, a recent series of studies (Lasauskaite, Gendolla, Bolmont, & Freydefont, 2017) tested for implicit associations between happiness and ease vs. sadness and difficulty in a sequential priming paradigm and found clear evidence for the affect-demand associations posited in the IAPE model (Gendolla, 2012, 2015).

Some of our previous experiments found prime effects on task performance that corresponded to those of cardiovascular effort measures (e.g., Chatelain & Gendolla, 2016; Framorando, & Gendolla, 2018a; Gendolla & Silvestrini 2010, 2011; Silvestrini & Gendolla, 2013). The present study did not find effects on response accuracy or reaction times. However, performance depends on more than effort—at least ability and strategy use are important additional factors (Locke & Latham 1990). That is, as in this study, effort does not automatically translate into performance outcomes. Finally, the affect primes had no

significant effects on the measures of conscious affect. Although we are aware that zero-effects do not permit firm conclusions, the lack of evidence for prime effects on conscious affect is in line with the IAPE model idea that affect primes can influence effort implicitly without eliciting conscious feelings.

In summary, our results contribute to the emerging research on moderator variables of automaticity in the context of effort mobilization by illustrating prime warning as another boundary condition of automatic effort mobilization—especially in men. In more general terms, the present study thus provides additional evidence that prime effects on behavior depend on implicit prime processing or the unawareness of priming procedures and their effects.

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Footnotes

[1] To have a more detailed picture of the self-reported measures, we also ran a separate 2 (Prime) x 2 (Warning) x 2 (Gender) ANOVA of the difficulty ratings, which revealed the same effects as the ANOVA of the ability index. There was a significant Warning main effect, $F(1, 157) = 4.31$, $p = .040$, $\eta^2 = .03$, 95% CI [0.024; 0.958], due to higher task difficulty ratings in the warning condition ($M = 3.29$, $SE = 0.15$) than in the no-warning condition ($M = 2.80$, $SE = 0.18$). Additionally, the main effect of Gender was significant, $F(1, 157) = 5.48$, $p = 0.02$, $\eta^2 = .03$, 95% CI [0.086; 1.02]. Women ($M = 3.33$, $SE = 0.18$) rated the task difficulty as higher than men ($M = 2.78$, $SE = 0.16$). No other effect was significant (ps > .39).

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Table 1
Means and standard errors (in parentheses) of the cardiovascular baseline values.

	Men			
	No-Warning		Warning	
	Sadness Primes (n = 22)	Happiness Primes (n = 21)	Sadness Primes (n = 21)	Happiness Primes (n = 21)
PEP	99.82(2.97)	102.57(2.54)	102.78(2.42)	95.49(2.24)
SBP	107.82(2.37)	105.11(1.56)	104.70(2.20)	109.56(1.82)
DBP	54.61(1.63)	56.29(1.29)	56.54(1.37)	56.33(1.15)
HR	71.44(1.97)	71.81(2.42)	69.75(2.17)	71.40(1.92)
	Women			
	No-Warning		Warning	
	Sadness Primes (n = 21)	Happiness Primes (n = 19)	Sadness Primes (n = 21)	Happiness Primes (n = 20)
PEP	104.89(2.66)	99.33(2.17)	100.92(1.67)	101.07(2.11)
SBP	100.94(2.11)	96.98(1.54)	100.89(2.55)	99.17(2.02)
DBP	56.38(1.69)	56.14(1.33)	56.59(1.77)	55.58(1.32)
HR	73.98(3.17)	74.07(2.94)	79.03(1.91)	71.50(2.37)

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 blood pressure reactivity during task performance.

	Men			
	No-Warning		Warning	
	Sadness Primes (n = 22)	Happiness Primes (n = 21)	Sadness Primes (n = 21)	Happiness Primes (n = 21)
SBP	6.10(1.24)	6.28(1.37)	6.51(1.46)	4.65(0.81)
DBP	3.28(0.91)	4.53(0.97)	4.15(0.71)	2.59(0.55)
	Women			
	No-Warning		Warning	
	Sadness Primes (n = 21)	Happiness Primes (n = 19)	Sadness Primes (n = 21)	Happiness Primes (n = 20)
SBP	6.05(1.32)	5.75(0.99)	4.00(0.98)	5.77(1.22)
DBP	4.61(0.65)	3.84(0.78)	4.20(0.82)	3.68(1.03)

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

Figure Captions

Figure 1. Cell means and ±1 standard errors underlying the Prime x Warning interaction effect on cardiac pre-ejection period reactivity (in ms) during task performance.

Figure 2. Cell means and ±1 standard errors underlying the Prime x Warning x Sex interaction effect on cardiac pre-ejection period reactivity (in ms) during task performance.

Figure 3. Cell means and ±1 standard errors underlying the Prime x Warning x Sex interaction effect on heart rate reactivity (beats/min) during task performance.

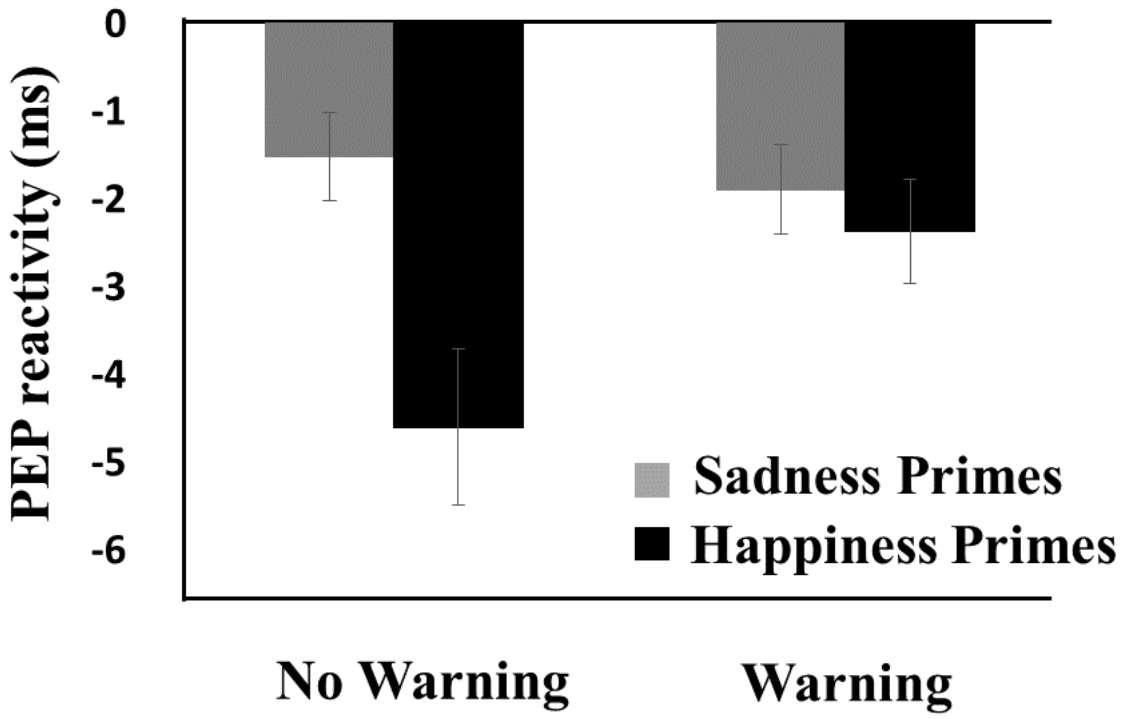
PEP reactivity (ms)
0
-1
-2
-3
-4
-5
-6
Sadness Primes
Happiness Primes
No Warning
Warning

Figure 1

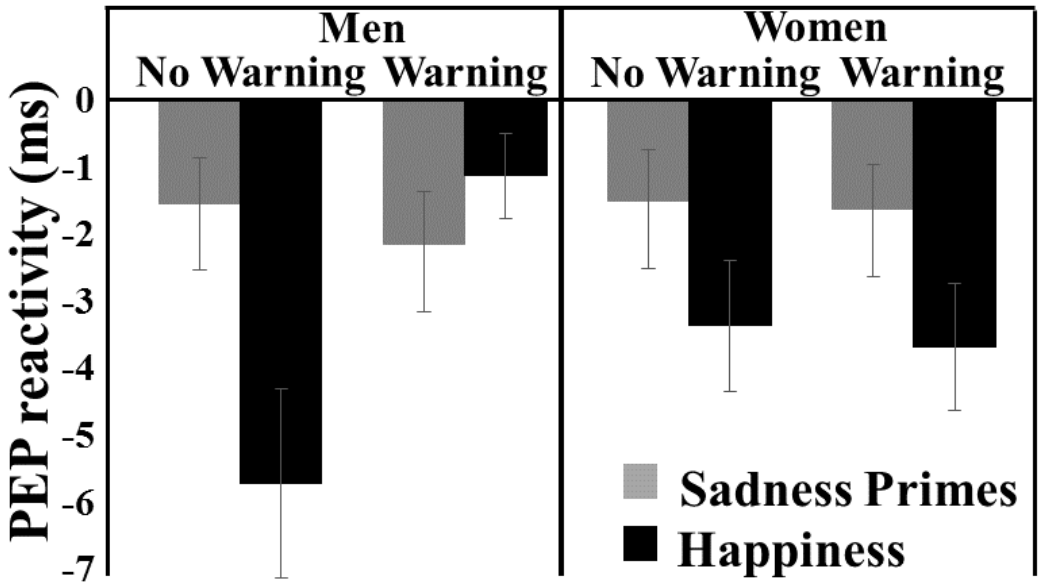
Men
No Warning
Warning
Women
No Warning
Warning
PEP reactivity (ms)
0
-1
-2
-3
-4
-5
-6
-7
Sadness Primes
Happiness

Figure 2

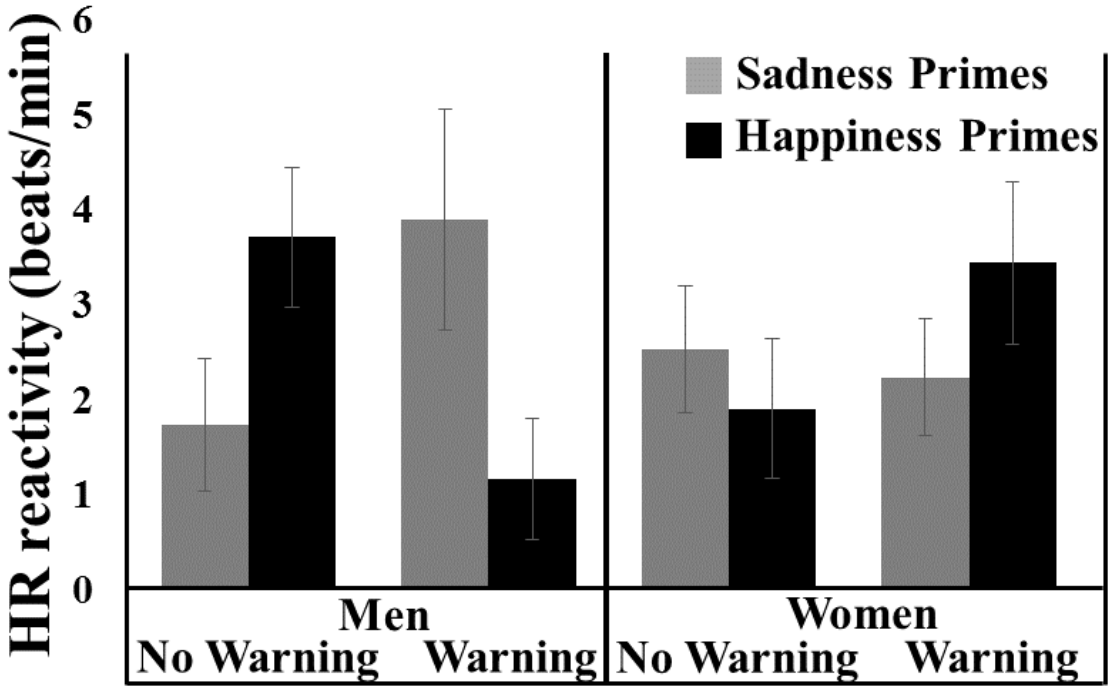

Figure 3