Running Head: Fear Primes, Incentive, and Effort

Monetary Incentive Moderates the Effect of Implicit Fear on
Effort-Related Cardiovascular Response

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Abstract

Integrating the implicit-affect-priming-effort model (Gendolla, 2012, 2015) with the principles of motivational intensity theory (Brehm & Self, 1989) we investigated if the effort mobilization deficit observed in participants exposed to fear primes (vs. anger primes) in a difficult short-term memory task could be compensated by high monetary incentive. Effort was operationalized as cardiac response. We expected that fear primes should lead to the strongest cardiac pre-ejection period (PEP) reactivity when incentive was high (high subjective demand and high justified effort) and to the weakest response when incentive was low (high subjective demand but only low justified effort). PEP reactivity in the anger-prime conditions should fall in between (moderate subjective demand). We obtained the predicted pattern on responses of PEP and systolic blood pressure. The present findings show for the first time that the effort mobilization deficit of participants exposed to fear primes in a difficult cognitive task could be compensated by a high incentive.

Introduction

Research on the implicit-affect-priming-effort (IAPE) model (Gendolla, 2012, 2015), has yielded growing evidence for the systematic impact of implicitly processed affective stimuli on effort-related cardiac response. It was found that processing sadness- or fear-priming in moderately difficult cognitive tasks led to stronger cardiac response than processing happiness- or anger-priming (e.g., Chatelain & Gendolla, 2015; Gendolla & Silvestrini, 2011; Lasauskaite, Gendolla, & Silvestrini, 2013). Besides these simple affect prime effects, it was also found that implicit affect's impact is not stable and can be moderated by task context variables, such as objective difficulty (Chatelain, Silvestrini, & Gendolla, 2016; Freydefont, Gendolla, & Silvestrini, 2012; Lasauskaite Schüpbach, Gendolla, & Silvestrini, 2014; Silvestrini & Gendolla, 2011c) and success incentive (Freydefont & Gendolla, 2012). Accordingly, these affect priming effects on effort are highly context-dependent. The present study aimed at testing if the previously found effort mobilization deficit shown by people performing a difficult task while being exposed to implicitly processed fear primes could be eliminated by high success-contingent incentive.

The IAPE model (Gendolla, 2012, 2015) posits that people acquire knowledge about emotions that is stored in long-term memory (Niedenthal, 2008). That is, people develop emotion concepts. In this process people learn to associate different affective states with performance ease or difficulty, which is typically experienced when they perform tasks in those states. Consequently, ease or difficulty become features of the mental representations of different emotions. Making the idea of "ease" or "difficulty" accessible as features of emotion concepts during task performance should result in experiences of low vs. high task demand. This, in turn, should influence effort mobilization according to the principles of motivational intensity theory (Brehm & Self, 1989): effort rises with subjective demand as long as success is possible and the necessary effort to succeed is justified.

More specifically, the IAPE model posits that happiness and anger are associated with ease whereas fear and sadness are associated with difficulty. This happens, because people make the experience that performing tasks in a happy mood appears to be easier than in a sad mood (see Gendolla & Brinkmann, 2005; Gendolla, Brinkmann, & Silvestrini, 2012). Moreover, anger is linked with high control and high coping potential whereas fear is linked with low control and low coping potential (Lerner & Keltner, 2001). Consequently, people should learn to associate anger with ease and fear with difficulty.

Evidence for Implicit Affect Effects on Effort-Related Cardiac Response

A number of studies have supported the IAPE model ideas, showing simple affect prime effects on effort-related cardiac response—especially cardiac pre-ejection period (PEP), which is the time interval between ventricular excitation and the opening of heart's left ventricular valve in a cardiac cycle (Berntson, Lozano, Chen, & Cacioppo, 2004). As expected, processing very briefly flashed sadness or fear expressions led to stronger PEP reactivity in attention or short term memory tasks than processing happiness- or anger-primers (e.g., Chatelain & Gendolla, 2015; Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013).

Further studies have found that objective task difficulty moderates these simple affect prime effects on effort-related cardiac response according to the principles of motivational intensity theory (Brehm & Self, 1989). In objectively easy tasks, sadness- and fear-primers lead to higher effort mobilization than happiness- or anger-primers. By contrast, happiness- and anger-primers result in stronger cardiac reactivity than sadness and fear primes in objectively difficult tasks (e.g., Chatelain et al., 2016; Freydefont et al., 2012; Lasauskaite Schüpbach et al., 2014; Silvestrini & Gendolla, 2011c; see also Blanchfield, Hardy, & Marcora, 2014). These effects were predicted, because the information about objective difficulty and the activation of the ease and difficulty concepts by the affect primes should have an additive effect on subjective demand during performance. Consequently, in an easy

task, sadness- and fear-primers should result in higher effort than anger- or happiness-primers, because subjective demand is high in the former priming conditions. By contrast, in difficult tasks, anger- and happiness-primers should lead to higher effort than sadness- and fear-primers, because the former result in high but feasible subjective demand, while the latter lead to excessive subjective demand, resulting in disengagement. That is, in objectively difficult tasks, implicit sadness and fear result in an effort-mobilization deficit.

The moderator effects of objective task difficulty on affect primes' effects on effort-related cardiac response accord with the principles of motivational intensity theory (Brehm & Self, 1989) in that effort rises with demand as long as success is possible and justified. However, if these principles really fit, justifying the necessary high subjective effort of people exposed to fear- and sadness-primers in a difficult task should eliminate the effort mobilization deficit and boost effort. Freydefont and Gendolla (2012) tested this idea by manipulating incentive by promising monetary reward for success on an objectively difficult short-term memory task during which participants processed sadness vs. anger primes. As expected, high incentive could eliminate the effort-mobilization deficit of people primed with sadness during the difficult task. Most relevant, the strongest PEP response occurred in the sadness-prime/high-incentive condition. Here, the high incentive justified the subjectively necessary high effort and could eliminate the effort mobilization deficit of people primed with sadness. Moreover, the weakest PEP response was found in the sadness-prime/low-incentive condition, reflecting disengagement because the subjectively high necessary effort was not justified. The two anger-prime conditions fell in between these cells. This was anticipated, because implicit anger should have set subjective demand to a high but feasible level. Consequently it was not necessary to justify higher effort and incentive had no effect. The major aim of the present research was testing if high incentive can also eliminate the effort mobilization deficit of people primed with fear during an objectively difficult task (see Chatelain et al., 2016).

Effort-Related Cardiovascular Response

Wright (1996) has integrated motivational intensity theory (Brehm & Self, 1989) with Obrist's (1981) active coping approach from psychophysiology. This led to the prediction that β -adrenergic sympathetic impact on the heart responds proportionally to the level of subjective task demand as long as success is possible and justified. The best noninvasive measure of β -adrenergic activity impact is cardiac PEP—the time interval between ventricular excitation and the opening of heart's left ventricular valve in a cardiac cycle (Berntson et al., 2004). PEP is cardiac contractility index, which becomes shorter with stronger contractility of the heart. Existing data support Wright's integrative hypothesis that PEP sensitively responds to variations in experienced task demand (Richter, Friedrich, & Gendolla, 2008), incentive value (Richter & Gendolla, 2009), and combinations of both (Silvestrini & Gendolla, 2011a). However, to assure that PEP responds as a function of β -adrenergic sympathetic impact rather than preload (ventricular filling) or afterload (arterial pressure) effects, blood pressure and heart rate (HR) should always be assessed together with PEP (Sherwood et al., 1990).

Several other studies have also operationalized effort as systolic blood pressure (SBP)—the maximal vascular pressure in a pulse wave—because SBP is systematically influenced by cardiac contractility (Gendolla & Richter, 2010; Wright & Kirby, 2001). However, SBP and diastolic blood pressure (DBP) are also influenced by peripheral vascular resistance, which is not systematically influenced by β -adrenergic impact and can be masked by it (Levick, 2003). Still, some other studies have quantified HR as measure of effort (Eubanks, Wright, & Williams, 2002). But HR is influenced by both sympathetic and parasympathetic nervous system activity, and should only reflect effort mobilization to the degree to which the sympathetic impact is stronger (Berntson, Cacioppo, & Quigley, 1993). Thus, PEP is the most valid and reliable indicator of effort mobilization among these

parameters (Kelsey, 2012).

The Present Experiment

To better understand the moderation of affect primes' effect on effort-related cardiac response by task context variables, the present experiment tested if the effort mobilization deficit observed when people implicitly process fear-primes during an objectively difficult cognitive task could be eliminated by success-contingent monetary incentive. Finding support for this effect would further sustain the idea that affect prime effects on effort-mobilization are context-dependent rather than fixed. In addition, we aimed at providing further evidence that affect prime effect are emotion-category specific rather than valence-specific (e.g., Chatelain & Gendolla, 2015; Chatelain et al., 2016; Freydefont et al., 2012; Freydefont & Gendolla, 2012). Therefore we investigated the effects of primes of two negative emotions, which are highly arousing—but which can lead to different patterns of physiological activation (see Kreibig, 2010 for a review). Participants worked on an objectively difficult version of a short-term memory task (Sternberg, 1966) during which they processed very briefly flashed facial expressions of fear vs. anger. To manipulate success incentive, participants expected a low vs. high monetary reward for successful performance. Our predictions, which are depicted in Figure 1, were based on the integration of the IAPE model (Gendolla, 2012, 2015) with the principles of motivational intensity theory (Brehm & Self, 1989).

In the low-incentive condition, depicted in Panel A of Figure 1, we expected the weakest PEP response in the fear-prime condition, because the subjectively high necessary effort was not justified, resulting in disengagement. Effort in the anger-prime condition should be higher, because the task should appear demanding but feasible. These effects correspond to those observed by Chatelain et al. (2016). Most relevant, as depicted in Panel B of Figure 1, high incentive should justify high effort. Therefore, we expected the strongest

PEP response in the fear-prime condition, where the very high subjectively necessary effort was now justified by the high incentive. PEP reactivity in the anger-prime condition should be lower, because subjective demand should be lower. Consequently, high incentive should not boost effort in the anger-prime condition, because here justifying high effort was not necessary to prevent disengagement. Altogether, this leads to the prediction that cardiac PEP reactivity should be the weakest in the fear-prime/low-incentive condition and the strongest in the fear-prime/high-incentive condition. The anger-prime conditions should fall into between these cells.

Method

Participants and Design

We aimed at collecting data of at least 20 participants per conditions (see Simmons, Nelson, & Simonsohn, 2011) and thus randomly assigned 82 voluntary university students with different majors in a 2 (Prime: fear vs. anger) x 2 (Incentive: low vs. high) between-persons design (61 women, 21 men, mean age 24 years). Participants received 10 Swiss Francs (approximately 11 USD) for their participation in the experiment. We removed 2 participants from the analyses because they took medication that could have influenced their cardiovascular responses, leaving a final sample of $N = 80$. Moreover, due to a technical error, one other participant had missing values for the self-report and performance measures. For the analyses of these variables, the final sample was thus $N = 79$. Participants' characteristics regarding sex and age were balanced between the experimental conditions: fear-prime/low-incentive condition (14 women, 6 men, mean age = 24), fear-prime/high incentive condition (14 women, 6 men, mean age = 23), anger-prime/low-incentive condition (15 women = 15, 5 men, mean age = 24), and anger-prime/high-incentive condition (16 women, 4 men, mean age = 24).

Affect Primes

We used pictures with averaged neutral (FNES = “female neutral straight”, MNES = “male neutral straight”), fear (FAFS = “female afraid straight”, MAFS = “male afraid straight”), and anger (FANS = “female angry straight”, MANS = “male angry straight”) front perspective, low resolution, grey-scale facial expressions from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998) as affect primes. Half the pictures showed male faces and half showed female faces. Examples of the stimulus material are depicted in Figure 1.

Apparatus and Physiological Measures

PEP was assessed with impedance cardiogram (ICG) and electrocardiogram (ECG) signals using a Cardioscreen 1000 system (medis, Ilmenau, Germany). Four pairs of disposable spot electrodes (Ag/AgCl, Medis, Ilmenau, Germany) were placed on the right and left side of the base of the participant’s neck and on the left and right middle axillary line at the height of the xiphoid. The signals were amplified and digitalized with a sampling rate of 1000 Hz, and analyzed offline with BlueBox 2.V1.22 software (Richter, 2010) applying a 50 Hz low pass filter. The first derivative of the change in thoracic impedance was calculated, and the resulting dZ/dt signal was ensemble averaged over periods of 1 min using the detected R-peaks (Kelsey & Guethlein, 1990). 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 milliseconds) 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.

In addition, SBP and DBP (in millimeters of mercury [mmHg]) were assessed with a Dinamap ProCare monitor (GE Medical Systems, Information Technologies Inc., Milwaukee, WI) that uses oscillometry. A blood pressure cuff placed over the brachial artery above the elbow of the participants’ nondominant arm was automatically inflated in 1-min intervals to

assess arterial pressure.

Procedure

The procedure of the experiment had been approved by the local ethical committee. Participants signed a consent form before being seated in a comfortable chair in front of a computer screen. Then, the experimenter attached the electrodes and the blood pressure cuff and went to an adjacent control room. The experiment was run in individual sessions and the whole procedure was computerized (E-Prime, Psychology Software Tools, Pittsburgh, PA). Instructions were displayed on the screen and participants gave their responses on a numerical keyboard. After answering biographical questions (age, sex, etc.), participants rated 2 items related to fear (frightened, anxious) and 2 items related to anger (angry, irritated) on 7-point scales (1—*not at all*, 7—*very much*) to assess their affective state before the exposure to the affect primes. This was followed by the recording of cardiovascular baseline activity. For this, cardiovascular measures were taken while participants watched a hedonically neutral documentary film about Portugal (8 min).

Next, we administered a short-term memory task adapted from Sternberg (1966). Participants were instructed to respond correctly and as fast as possible. Success incentive was manipulated as follows: After 10 practice trials of the task, participants learnt that they could earn 1 Swiss Franc (i.e. about USD 1) in the low-incentive condition vs. 15 Swiss Francs (i.e. about USD 15) in the high-incentive condition if they met the success criterion of at least 90% correct responses (“If you succeed in at least 90%, you will win ...”).

Each trial started with a fixation cross (1000 ms) followed by a facial expression of the AKDEF database (27 ms; i.e. 2 frames on a 75 Hz monitor). In each condition, 1/3 of the flashed faces were emotional (fear vs. anger) whereas the other 2/3 were neutral expressions—which has been found to be the most effective priming manipulation in the present paradigm (Silvestrini & Gendolla, 2011b). The facial expressions were immediately

backward masked with a random dot pattern (133 ms). A second fixation cross appeared for 1000 (ms) which was followed by a string of 7 letters presented for 750 ms. Afterwards, a target letter appeared in the middle of the screen and a row of the letter “X” masked the previously presented letter string. Participants had to indicate by pressing a “yes” or “no” key on the numerical keyboard with the fingers of their choice of their dominant hand if the target letter was part of the previously presented string of letters or not. The target letter remained on the screen for maximally 2000 ms. After participants had responded, the message “response entered” was displayed while the phrase “please answer more quickly” appeared in case of no response within the 2000 ms response time window. To assure that each participant worked on the task for the same time, the respective message appeared for 4 sec. minus participants’ reaction time. The inter-trial interval randomly varied between 2 and 4 sec.

The task comprised 32 trials and lasted 5 minutes. Participants received correctness feedback in the 10 practice trials they performed before the main task. In these practice trials, only neutral facial expressions appeared as primes. During the main task, no correctness feedback was given in order to prevent possible affective reactions, which could interfere with the effect of manipulation (e.g., Kreibitz, Gendolla, & Scherer, 2012). To calibrate task difficulty, we considered that memorizing letter strings taxes working memory—processing more letters demands more working memory capacity. Given that the average capacity of short-term memory span seems to be 4 to 5 items (Cowan, 2000), we decided to display 7 letters in the task to make it difficult. This manipulation had also been successfully applied to manipulate difficult versions of the Sternberg task in two of our previous studies (Freydefont et al., 2012; Freydefont & Gendolla, 2012).

After the task, participants rated subjective task difficulty and the importance of success on 7-point scales (1—*not at all*, 7—*very much*). Then, we took the same affect measures as at the beginning of the procedure in order to control for possible affect prime

effects on participants' conscious feelings. Moreover, we administered questions about possible medication, hypertension history in their family, and their smoking habits.

At the end of the experiment, participants were asked in a standardized funnel debriefing procedure about the study's purpose and what they had seen during the task. If they mentioned "flickers" the experimenter asked them to describe their content to know to which extent they had been aware of the content of the affect primes. Finally, participants were debriefed, thanked, and received their remuneration.

Data Analysis

We tested our prediction of the anticipated pattern of effort-related cardiac response with contrast analysis, which is the most powerful and thus most appropriate statistical tool to test complex interactions (Rosenthal & Rosnow, 1985; Wilkinson and the Task Force for Statistical Inference, 1999). As mentioned above, we aimed at testing if the effort-mobilization deficit of participants exposed to fear primes during a difficult task could be eliminated by high performance-contingent incentive. As depicted in Figure 1, we thus predicted the lowest effort due to disengagement for the fear-prime/low-incentive condition (contrast weight = -2) and the highest effort in the fear-prime/high-incentive condition (contrast weight = +4), because here the subjectively high necessary effort was justified. Effort in both anger-prime conditions should fall in between these conditions, because the subjectively necessary effort was expected to be moderate and incentive should thus not influence effort-related cardiac response (contrast weights = -1).

Other variables, for which we had no theory-based a priori predictions, were analyzed with conventional exploratory 2 (Prime) x 2 (Incentive) between-persons ANOVAs. In the analysis of the affect ratings, we added a time factor, resulting in 2 (Prime) x 2 (Incentive) x 2 (Time) mixed model ANOVAs. The alpha-error level for all tests was 5%. For reasons of consistency and easier comparability of effect sizes, we transformed effect size

coefficients r for tests with 1 degree of freedom (between participants) to coefficients η^2 .

Results

Cardiovascular Baselines

Repeated-measures ANOVAs of the eight 1-min scores of PEP, HR, SBP, and DBP collected during the baseline assessment period revealed significant Time main effects, $F_s > 2.46$, $p_s < .02$, $\eta^2 > .06$, due to significant decreases in cardiovascular activity after the beginning of the habituation period. Thus, we constituted baseline scores by averaging the cardiovascular activity values of the last six minutes, which did not differ significantly according to Tukey tests ($p_s > .12$) and showed high internal consistency (Cronbach's $\alpha_s > .97$). Cell means and standard errors appear in Table 1.

Exploratory 2 (Prime) $\times$ 2 (Incentive) between-persons ANOVAs did not reveal any significant baseline differences between the conditions for PEP and HR ($p_s > .26$). However, we found trends to Incentive main effects on the SBP and DBP baselines ($p \leq .054$) with which we will deal with ANCOVAs reported below. We did not include sex as a factor in the analyses due to the limited number of men in our sample. However, the results were the same if we considered only women in the analyses.

Cardiovascular Reactivity

We computed task scores by averaging the 1-min scores of each cardiovascular index assessed during task performance (Cronbach's $\alpha_s > .94$) and created reactivity scores by subtracting baseline values from those task scores. Preliminary ANCOVAs of the reactivity scores revealed a significant association between baseline values and reactivity scores for HR, $F(1, 75) = 5.80$, $p = .018$, $\eta^2 = .07$, but not for the other cardiovascular indices ($p_s > .09$). Therefore, we introduced the HR baselines as covariate in the analysis of HR reactivity to prevent law of initial values or carry-over effects.

PEP Reactivity

Our theory-based a priori contrast was significant for PEP reactivity, our primary measure of effort mobilization, $F(1, 76) = 5.46, p = .022, \eta^2 = .07$. The test of the residual was not significant ($F < 1.10$), showing that the contrast left no significant variance unexplained. As depicted in Figure 2, the PEP responses showed the anticipated pattern. PEP reactivity was the weakest in the fear-prime/low-incentive condition ($M = -1.17, SE = 0.51$), which was expected because the high effort that should have been required due to high subjective demand was not justified by the low incentive. On the contrary, the fear-prime/high-incentive condition showed the strongest PEP reactivity ($M = -5.34, SE = 1.33$). This was anticipated, because here the high incentive justified the high necessary effort. PEP response in the anger-prime/low-incentive ($M = -3.52, SE = 1.18$) and the anger-prime/high incentive conditions ($M = -3.72, SE = 1.11$) fell in between these cells, which was expected because the anger primes should set subjective demand to a high but feasible level, making it unnecessary to be justified by high incentive.

Additional focused comparisons revealed a significant difference between the modest PEP reactivity in the fear-prime/low-incentive condition and the strong reactivity in the fear-prime/high incentive cell, $t(76) = 2.74, p = .004, \eta^2 = .09$. The anger-prime conditions did not differ significantly ($p = .448$). Moreover, the moderate reactivity in the two anger-prime conditions differed significantly from the low reactivity in the fear-prime/low-incentive cell, $t(76) = 1.86, p = .033, \eta^2 = .04$, and by trend from the strong reactivity in the fear-prime/high-incentive condition, $t(76) = 1.31, p = .098, \eta^2 = .02$.

SBP Reactivity

The a priori contrast was significant, $F(1, 76) = 6.21, p = .015, \eta^2 = .08$, whereas the test of residual variance was not ($F < 1$). As described in Figure 3, the pattern of SBP reactivity corresponds to that of PEP reactivity and fits our effort-related predictions.

Moreover, additional comparisons revealed that the difference between the fear-prime/low-incentive ($M = 2.67$, $SE = 0.92$) and the fear-prime/high-incentive conditions ($M = 6.79$, $SE = 1.35$) was significant, $t(76) = 2.64$, $p = .005$, $\eta^2 = .08$. In addition, there was no significant difference between the anger-prime/low-incentive ($M = 4.44$, $SE = 1.11$) and the anger-prime/high-incentive ($M = 4.48$, $SE = 0.97$) cells ($p = .487$). The moderate reactivity in the two anger-prime cells differed significantly from the high reactivity in the fear-prime/high incentive cell, $t(76) = 1.72$, $p = .044$, $\eta^2 = .04$, and by trend from the low reactivity in the fear-prime/low-incentive cell, $t(76) = 1.33$, $p = .094$, $\eta^2 = .02$.

HR and DBP Reactivity

As presented in Table 2, the reactivity patterns of HR and DBP corresponded to that of PEP and SBP. However, the a priori contrast for HR reactivity with the HR baselines as covariate fell short of significance, $F(1, 75) = 3.48$, $p = .066$, (residual $F < 1$). On DBP, neither the a priori contrast, $F(1, 76) = 1.75$, $p = .189$, nor the test of the residual was significant ($F < 1$).

Task Performance

A 2 (Prime) x 2 (Incentive) ANCOVA of the percentage of correct responses, with the share of correct responses during practice trials as covariate to control for individual differences before the manipulations, did not reveal any significant effects ($ps > .11$; average $M = 84\%$, $SE = 1.14$). It is of note that only 27% of the participants met the 90% correct responses success standard and obtained the monetary incentive, suggesting that objective task difficulty was effectively high.

A 2 (Prime) x 2 (Incentive) ANCOVA of the reaction times for correct responses revealed a strong association between reaction times during the task and the practice trials, $F(1, 74) = 60.54$, $p < .001$, $\eta^2 = .45$. As depicted in Figure 4, the pattern of reaction times corresponded to that of PEP and SBP reactivity. Thus, we applied the same a priori contrast as

for these cardiovascular measures, which was significant, $F(1, 74) = 4.24, p = .043, \eta^2 = .05$, (residual $F < 1$).

Additional comparisons revealed that responses in fear-prime/high-incentive condition ($M = 988.28, SE = 45.37$) were made significantly faster than in the fear-prime/low-incentive condition ($M = 1101.18, SE = 38.29$), $t(74) = 1.72, p = .045, \eta^2 = .04$. In the anger-prime condition, the low-incentive ($M = 1082.00, SE = 55.08$) and high-incentive cells ($M = 1114.13, SE = 43.71$) did not differ significantly ($p = .314$). Moreover, the reaction times in the two anger-prime cells differed significantly from those in the fear-prime/high-incentive condition, $t(74) = 1.95, p = .027, \eta^2 = .05$, but not from those in the fear-prime/low-incentive cell ($p = .478$).

Affect Ratings

To compute affect scores, we averaged the two pre-task and post-task fear- ($rs > .78$) and anger- ($rs > .52$) related items and performed 2 (Prime) x 2 (Incentive) x 2 (Time) mixed model ANOVAs for both scales. The analysis of the fear scores revealed a significant Prime x Time interaction, $F(1, 75) = 4.08, p = .047, \eta^2 = .05$. However, Tukey tests did not reveal any significant differences between pre-task and post-task measures in the anger-prime ($M = 1.78, SE = 0.19$ vs. $M = 2.01, SE = 0.22; p = .395$) and fear-prime conditions ($M = 1.91, SE = 0.19$ vs. $1.62, SE = 0.13; p = .595$). This does not lend any support to the possibility that the priming manipulation had induced conscious emotional feelings. No other effects were significant ($ps > .25$). Also the ANOVA of the anger scores yielded a Prime x Time interaction, $F(1, 75) = 9.21, p = .003, \eta^2 = .11$. However, as for the fear scores, Tukey tests did not provide any evidence for significant changes in conscious anger due to the priming procedure—neither in the anger-prime ($M = 1.19, SE = 0.07$ vs. $M = 1.50, SE = 0.15; p = .334$) nor in the fear-prime condition ($M = 1.49, SE = 0.17$ vs. $1.29, SE = 0.12; p = .057$). Other ANOVA effects were not significant ($ps > .12$).

We additionally tested with ANCOVAs for significant associations between the post-task affect scores and PEP and SBP reactivity. We did not find any such significant associations ($ps > .09$). Moreover, the a priori contrasts for PEP and SBP reactivity remained significant after controlling for the post-task fear and anger ratings, $F_s(1, 74) > 5.43$, $ps < .03$, $\eta_s^2 > .06$, meaning that the significant manipulation effects on these cardiovascular measures are hardly explicable by conscious fear or anger.

Task Ratings

A 2 (Prime) x 2 (Incentive) ANOVA of the difficulty ratings did not reveal significant effects ($ps > .29$; average $M = 3.72$, $SE = 0.16$). The same applied to the ANOVA of the success importance ratings ($ps > .30$; average $M = 5.30$, $SE = 0.15$).

Funnel Debriefing

In the funnel debriefing, no participant was able to properly guess the purpose of the study. When asked to describe a trial, 87% of the participants mentioned having seen faces during the task. Nevertheless, only 40% of them reported to have identified men and women and only 11% of them (i.e., 8 participants in total) indicated to have seen emotional faces. This suggests that 90% of the participants had processed the affect primes without awareness of their emotional content.

Discussion

The purpose of the present study was to test if high monetary incentive could eliminate the effort mobilization deficit of people who implicitly process fear-primes during a difficult cognitive task (see Chatelain et al., 2016). The present effects on cardiac PEP response, our primary measure of effort mobilization (Kelsey, 2012; Wright, 1996), and SBP, which is systematically influenced by cardiac contractility and thus PEP, support this idea. Participants primed with fear during a difficult short-term memory task showed the weakest PEP and SBP responses when incentive was low, but the strongest reactivity when incentive

was high. The PEP and SBP responses in both anger-prime conditions fell in between these cells and were not affected by the incentive manipulation. Corresponding effects of sadness vs. anger primes and high vs. low incentive were previously found by Freydefont and Gendolla (2012). That is, the present findings provide replicated evidence that incentive moderates the impact of implicit affect on effort mobilization during a difficult cognitive task.

Based on an integration of the IAPE model (Gendolla, 2012, 2015) with motivational intensity theory (Brehm & Self, 1989), the reason for the expected pattern of cardiovascular response was that the affect primes should influence subjective demand during performance together with objective task difficulty and that incentive should determine the level of justified effort. Effort should then rise with subjective demand as long as success was possible and justified. More specifically, during performance on an objectively difficult cognitive task, participants primed with fear should experience high subjective demand. When incentive was low, the resulting high subjectively necessary effort should not have been justified, resulting in disengagement. By contrast, high incentive should have justified the high necessary effort, resulting in the mobilization of high resources. However, priming participants with anger should set subjective demand and required effort at a high but feasible level, which was lower than in the sadness-prime condition. Thus, it was not necessary to justify the subjectively necessary effort with high incentive.

The present findings are important for several reasons. First, they contribute to the accumulating evidence for the systematic impact of implicit affect on effort mobilization as posited in the IAPE model (Gendolla, 2012). Other lines of research have reported evidence that a number of psychological variables can systematically influence subjective demand and thus effort in cognitive tasks. Examples are ability beliefs (e.g., Wright & Dill, 1993), fatigue (e.g., Wright, Martin, & Bland, 2003), mood (e.g., Gendolla & Brinkmann, 2005), depression (e.g., Brinkmann & Gendolla, 2008), mania (e.g., Harmon-Jones et al., 2007), or extraversion

(e.g., Kemper et al., 2008). The present study contributes to the accumulating evidence for the systematic impact of implicitly processed affective stimuli on effort-related cardiac response. Second, the present findings contribute to a better understanding of automaticity in behavior in general, because they highlight moderating conditions of implicit affect's impact on motivational intensity (see Gendolla, 2015). Third, they support the IAPE model idea that implicit affect takes its effect on effort mobilization through its impact on subjective demand, rather than by taxing objective cognitive capacity—capacity cannot grow through incentive, but incentive can justify high necessary effort. Fourth, the present findings add to the evidence that the effects of implicit affect on effort are emotion-category rather than valence-specific. Fear and anger are both negative emotions, which are both associated with high arousal (see Kreibitz, 2010), but their impact on effort mobilization was obviously different.

Interestingly, although there was no significant effect on the number of correct responses in the short-term memory task, participants' performance in terms of reaction times mirrored the effects on the PEP and SBP responses. That is, in the present experiment effort apparently brought return. Previously, we have found corresponding affect prime effects on effort and performance in only some of our studies (Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013). However, also if one intuitively expects correspondences between effort (i.e. input) and performance (i.e. output), it is of note that the effort-performance relationship is complex. Effort is the mobilization of resources to carry out instrumental behavior while performance only describes the outcome of instrumental behavior. This is an important conceptual difference. Additionally, performance depends on strategy, ability, and effort rather than on effort alone (Locke & Latham, 1990). In general, as pointed out by Silvestrini and Gendolla (2013), it should be more likely to observe variations in effort concomitantly with performance in objectively difficult tasks, which are less capacity-determined than easy (everybody has sufficient capacity) and extremely difficult tasks (nobody has sufficient

capacity). Therefore the correspondence of effects on our effort and performance measures makes sense in the present study that administered an objectively difficult task. However, one should not always expect that effort and performance correspond.

In contrast to PEP and SBP, we did not find significant effects on DBP and HR—though the pattern of effects largely corresponded to that of PEP and SBP. The effects on SBP are in accordance with a bulk of studies that have found effort-related effects on SBP (see Gendolla, Wright, & Richter, 2012; Richter, Gendolla, & Wright, *in press*; Wright & Gendolla, 2012), which is systematically influenced by cardiac contractility (Wright, 1996). However, SBP is also influenced by peripheral vascular resistance, which is not systematically influenced by beta-adrenergic sympathetic impact. Therefore, PEP is more sensitive and reliable cardiovascular index of effort mobilization (Kelsey, 2012). Also the absence of significant effects on HR and DBP is not surprising. HR is influenced by both parasympathetic and sympathetic autonomic nervous system activity. Therefore, HR should reflect effort mobilization only when the sympathetic impact is stronger, which is not always the case in cognitive tasks, which usually evoke only modest changes in HR (Berntson et al., 1993). DBP is still more strongly influenced by total peripheral resistance than SBP (Levick, 2003), and therefore a very noisy measure of effort. However, physiologically it is most important that decreases in PEP were not accompanied by decreases in DBP or HR, making it implausible to assume that PEP was influenced by preload (ventricular filling) or afterload (arterial pressure) effects instead of beta-adrenergic sympathetic impact (see Sherwood et al., 1990).

The IAPE model (Gendolla, 2012, 2015) posits that affect primes activate ease and difficulty concepts, which in turn influence subjectively experienced task difficulty and thus effort according to the principles of the motivational intensity theory (Brehm & Self, 1989). However, in the present study, it could be critically raised that we did not find a prime effect

on the post task ratings of subjective task difficulty. In our past studies, we have sometimes found affect prime effects on subjective demand ratings (e.g., Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013, 2014; Silvestrini & Gendolla, 2011c) or subjective effort (e.g., Chatelain & Gendolla, 2015), but not in others (e.g., Freydefont & Gendolla, 2012; Freydefont et al., 2012). However, ratings of subjective demand are assessed retrospectively, which makes this measure vulnerable to several biases (Robinson & Clore, 2002). Moreover, affect prime effects on task demand are expected to be automatic, suggesting that a more implicit measure of associations between affect primes and task demand in terms of performance ease or difficulty would be more appropriate as retrospective self-report measures. Interestingly, such associative links have recently been reported for sadness and difficulty and happiness and ease in a sequential priming paradigm (Lasauskaite, Gendolla, Bolmont, & Freydefont, 2016).

As in our previous studies on implicit affect effects on effort mobilization, we have not found any evidence for affect prime effects on conscious emotional feelings. This is in line with the mechanism postulated by the IAPE model, according to which the mere activation of emotion knowledge is sufficient to influence effort mobilization. Also the pattern of cardiovascular responses does not support the idea that the exposure to affect primes elicited emotional reactions. A study that investigated anger effects on cardiovascular reactivity in a cognitive task found that feelings of anger were accompanied by significant increases in HR and DBP (Bongard, Pfeiffer, Al'Absi, Hodapp, & Linnenkemper, 1997). This is not what we have found. Moreover, the funnel debriefing procedure revealed that 90% of the participants processed the affect primes without awareness of their emotional content. This further supports the idea that the here-reported effects on effort were implicit in nature. Thus, in summary, we interpret the present findings as another demonstration that the impact of implicit affect on effort mobilization is systematically moderated by task context variables.

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Table 1

Means and Standard Errors (in Parentheses) of the Cardiovascular Baseline Values.

	Fear Primes		Anger Primes	
	Low incentive	High Incentive	Low Incentive	High Incentive
PEP	99.85 (1.96)	97.35 (2.21)	99.02 (2.08)	101.37 (2.39)
SBP	107.89 (1.97)	104.24 (2.83)	104.58 (2.88)	99.02 (1.37)
DBP	60.17 (1.31)	58.41 (1.26)	61.37 (1.46)	57.65 (1.49)
HR	71.91 (2.18)	72.37 (3.00)	74.66 (2.72)	71.06 (2.42)

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 Heart Rate and Diastolic Blood pressure During Task Performance.

	Fear Primes		Anger Primes	
	Low incentive	High Incentive	Low Incentive	High Incentive
HR	3.12 ^a (0.56)	5.20 ^a (1.06)	4.26 ^a (0.88)	3.01 ^a (0.72)
DBP	2.78 (0.53)	4.26 (1.10)	3.28 (0.65)	3.07 (0.91)

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

^a Baseline-adjusted.

Figure Captions

Figure 1: Theoretical predictions for the combined effect of fear (gray line) vs. anger (black line) affect primes and success incentive on effort mobilization on different objective task difficulty levels. Panel A shows predictions for low incentive; Panel B shows predictions for high incentive. The predicted effort levels for objectively highly difficult tasks, which are relevant for the present experiment, are marked by the gray boxes.

Figure 2. Cell means and standard errors of cardiac pre-ejection period reactivity (in ms) during task performance.

Figure 3. Cell means and standard errors of systolic blood pressure reactivity (in mmHg) during task performance.

Figure 4. Cell means and standard errors of reaction times (in ms) for correct responses adjusted for practice trials' reaction times.

Figure 1

Figure 2

Figure 3

Figure 4