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Personal Task Choice Attenuates Implicit Happiness Effects on Effort:

A Study on Cardiovascular Response

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Abstract

Research on the Implicit-Affect-Primes-Effort model (Gendolla, 2012) found that priming happiness or anger in challenging tasks results in stronger sympathetically mediated cardiovascular responses, reflecting effort, than priming sadness or fear. Recent studies on action shielding revealed that personal task choice can attenuate affective influences on action execution (e.g., Gendolla et al., 2021). The present experiment tested if this action shielding effect also applies to affect primes' influences on cardiovascular response. Participants (*N* = 136) worked on a cognitive task with integrated facial expressions of sadness vs. happiness. Half of the participants could ostensibly choose whether they wanted to work on an attention or on a memory task, while the other half was assigned to one task. Our findings revealed effects on cardiac pre-ejection period (PEP), which align with the expected outcomes for a task of unfixed difficulty where participants establish their own performance standard. Most importantly, task choice shielded against the implicit affective influence on PEP that was evident when the task was assigned. Effects on systolic blood pressure (SBP) reactivity largely corresponded to those of PEP.

Keywords: Cardiovascular response, action shielding, implicit affect, pre-ejection period, effort

Introduction

Extensive research on the Implicit-Affect-Primes-Effort (IAPE) model (Gendolla, 2012) has revealed ample evidence that affective stimuli that are implicitly processed during cognitive tasks systematically influence sympathetically mediated responses in the cardiovascular system (see Gendolla et al., 2012, 2019; Silvestrini & Gendolla, 2019, for overviews). These responses reflect effort—the mobilization of resources for action execution (Gendolla & Wright, 2009). The theoretical basis for these findings is that individuals learn in their everyday lives that coping with challenges is easier in some affective states than in others. As a result, ease and difficulty become associated with specific affective states: Happiness and anger become associated with ease, and sadness and fear become associated with difficulty. Consequently, performance ease and difficulty become features of mental representations of different affective states. Based on the semantic priming principle (see Förster & Liberman, 2007; Neely, 1977), affect primes that are implicitly processed during a task can render the concepts of ease or difficulty accessible (Lasauskaite et al., 2017), leading to lower or higher subjective task demand. In line with Motivational Intensity Theory (Brehm & Self, 1989), the IAPE model posits that effort increases with the task demand as long as success is possible, and the necessary effort is justified. Consequently, complying with the principle to avoid wasting resources, the motivational intensity theory predicts disengagement and low effort if the necessary effort for success is not justified by the importance of success or if a task is over-challenging.

More specifically, the IAPE model predicts that sadness or fear primes processed during task performance should activate the difficulty concept and thus increase task demand, while happiness and anger primes should activate the ease concept, decreasing the level of subjective task demand. Thus, in easy to moderately difficult tasks, sadness and fear primes should intensify effort, whereas happiness and anger primes should decrease it (Chatelain & Gendolla, 2015; Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011a). Importantly, these prime effects should be inverted when a task is objectively difficult. Here, happiness and anger primes should lead to high effort because task difficulty is high but feasible, whereas sadness and fear primes should result in low effort because subjective task demand is excessively high, leading to disengagement (Chatelain & Gendolla, 2016a; Freydefont et al., 2012; Lasauskaite Schüpbach et al., 2014; Silvestrini & Gendolla, 2011b)—unless the high necessary effort becomes justified by high importance of success. Direct evidence for these hypotheses exists for the impact of high monetary incentives (Chatelain & Gendolla, 2016; Freydefont & Gendolla, 2012), but also other variables have been shown to have corresponding effort justification effects (e.g., ego-involvement, social evaluation, self-awareness, hedonic incentive; see Gendolla et al., 2012, 2019; Richter et al., 2016 for reviews).

Action Shielding

Despite the evidence for systematic affective influences on effort-related cardiovascular responses, theorizing and research on volition—the execution, maintenance, and protection of goal-directed action (Kuhl, 1986)—suggests that the formation of intentions activates a set of cognitive processes that support goal attainment (Gollwitzer, 1990; Heckhausen & Gollwitzer, 1987). Once committed to a goal or action, individuals enter a mindset that facilitates goal attainment with a strong task focus and goal shielding that protects goal pursuit from interferences, such as conflicting goals, temptations, or irrelevant information. This shielding effect has been demonstrated in research on goal conflict, where goal commitment protects against the mental activation of alternative goals (e.g., Shah et al., 2002) and aligns with research emphasizing the crucial role of personal choice in terms of agency (Bandura, 1986, 2001) or autonomy (Ryan & Deci, 2006; Ryan et al., 2021). Importantly, recent research found that this action shielding effect also applies to the impact of incidental affective influences on action execution and especially sympathetically mediated responses in the cardiovascular system.

Shielding Against Affective Influences

Research grounded in an action shielding model (Gendolla et al., 2021) found that individuals who personally chose the type of task (ostensible choice between an attention or memory task) or task aspects (stimulus color or typeface) were protected against the effects of mood inductions through happy vs. sad background music on cardiovascular responses reflecting effort during task performance. However, individuals to whom the task or its characteristics were externally assigned—which is the typical procedure in psychology experiments—showed music-induced mood effects on effort (Falk et al., 2022a, 2022b; Gendolla et al., 2021). Correspondingly, Falk et al. (2023) found that the personal choice of task characteristics led to shielding against the effect of displeasant acoustic noise on sympathetically mediated cardiovascual responses reflecting effort.

There is also first evidence for a shielding effect against affect primes' influences on effort in fixed difficulty contexts (Framorando et al., 2023a, 2023b). In those studies, participants worked on a moderately difficult or highly difficult task that was either personally chosen or externally assigned. Half of the participants were presented with fear or sadness primes, while the other half processed anger primes during task performance. In the moderately difficult task the fear primes resulted in stronger sympathetically mediated cardiac responses than the anger primes when the task was externally assigned (Framorando et al., 2023a)—a replicated effect (Chatelain &

Gendolla, 2015). Most importantly, the affect primes' effect disappeared when participants had personally chosen their task. A corresponding effect was found for primed cognitive conflict, which is aversive, vs. primed non-conflict (Bouzidi & Gendolla, 2023a, 2023b). In a highly difficult task context, Framorando et al. (2023b) successfully replicated the effect by contrasting sadness vs. anger primes instead of fear versus anger primes. The study revealed that anger primes lead to a stronger sympathetically mediated cardiac response than sadness primes when the task was externally assigned (Freydefont et al., 2012). Again, this affect prime effect was no longer observed when participants had personally chosen their task. Here, effort was high because personal task choice increased the commitment to succeed (Nenkov & Gollwitzer, 2012), which justified the exertion of high effort (Bouzidi et al., 2022).

Summing up, apart from the numerous other motivational effects of personal choice (see Leotti et al., 2010; Patall, 2012, 2019; Patall et al., 2008, for overviews), there is replicated evidence that individuals who choose tasks or task characteristics on their own become immune to incidental affective influences on action execution. Prompted by the first evidence that personal task choice could even shield against the effects of implicitly processed fear, sadness, and anger primes on sympathetically mediated cardiovascular response during task performance, our present study tested whether this action shielding effect also applies to happiness primes' influence on effort.

Effort and Cardiovascular Response

According to Wright's (1996) integration of motivational intensity theory (Brehm & Self, 1989) with considerations about psychophysiological responses in active coping situations (Obrist, 1981), effort intensity can be operationalized by indicators of beta-adrenergic sympathetic impact on the heart. Beta-adrenergic sympathetic activity impacts cardiac contractile force, which is especially mirrored by the pre-ejection period (PEP)—the time interval between the onset of left ventricular depolarization and the opening of the left aortic valve (Berntson et al., 2004). PEP becomes shorter when the beta-adrenergic impact becomes stronger.

Several studies have also used systolic blood pressure (SBP) to measure effort, because cardiac contractile force affects cardiac output (the volume of blood pumped by the ventricles per minute) and thus the maximal vascular pressure following a heartbeat (Gendolla et al., 2012; Richter et al., 2016, for overviews). 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 et al., 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, PEP is the purest measure of effort among these indicators, because it directly reflects beta-adrenergic sympathetic impact on the heart (Kelsey, 2012; Richter et al., 2008; Wright, 1996). Nevertheless, blood pressure and HR should be always measured along with PEP to monitor possible preload (ventricular filling) or afterload (arterial pressure) effects (Sherwood, 1990). One should attribute PEP responses to beta-adrenergic sympathetic impact only if decreases in PEP are not accompanied by simultaneous decreases of diastolic blood pressure or HR.

The Present Experiment

The present study aimed to test whether personal task choice can shield against implicitly processed sadness and happiness primes' effect on effort-related cardiovascular response, especially PEP, in a difficult cognitive task. Participants were asked to detect and count 19 vowels amongst multiple series of letters, which was initially estimated to correspond to an objectively fixed and difficult task. As in previous studies (Falk et al., 2022a; Framorando et al., 2023a, 2023b; Gendolla et al., 2021) half of the participants could ostensibly choose between two tasks (attention or memory), while the other half were assigned to the task type chosen by a yoked participant in the Chosen Task condition. All participants completed the same letter counting task, which comprised both attention and memory components. Task trials started with the presentation of briefly flashed and backward masked pictures of facial expressions. Half of the participants were presented with sad faces, while the other half were exposed to happy faces.

Based on the IAPE model (Gendolla, 2012) and our action shielding model (Gendolla et al., 2021), we expected stronger sympathetically mediated cardiovascular reactivity in the Happiness Primes condition than in the Sadness Primes condition when the difficult task was externally assigned (e.g., Silvestrini & Gendolla, 2011b; see also Framorando & Gendolla, 2019a; Lasauskaite Schüpbach et al., 2014). As outlined above, this is because sadness primes should lead to excessive subjective task demand and thus disengagement, while happiness primes should result in high but feasible task demand. Importantly, we expected the affect primes to have little effect when participants could personally choose the task, as they should then be shielded against experimentally induced mood influences (Gendolla et al., 2021), and even the effect of affect primes (e.g., Framorando et al., 2023a, 2023b). In this context, task choice should lead to an increased commitment to succeed on the task (Nenkov & Gollwitzer, 2012). Following the principles of motivational intensity theory (Brehm & Self, 1989), this should justify the high effort that is necessary for performing well on an objectively difficult task (Gendolla & Richter, 2010; see Bouzidi et al., 2022), and thus lead to relatively strong sympathetically mediated cardiovascular reactivity in both chosen task conditions. Altogether, these hypotheses result in the prediction of a 3:1 pattern with weaker cardiovascular reactivity (especially PEP) in the Assigned Task/Sadness Primes condition than in the other three conditions.

Method

Participants and Design

Previous experiments on affect priming and task choice found medium-sized significant effects on sympathetically mediated cardiovascular responses with samples of 20-30 participants per between-persons condition (e.g., Falk et al., 2022a, 2022b; Framorando & Gendolla, 2018a; Gendolla et al., 2021). To have the same sample size and to account for any possible data loss due to technical problems, we aimed to recruit at least 30 participants per condition. As a result, a total of 136 healthy students were enrolled in the study and were randomly assigned to one of four experimental conditions in a 2 (Choice: chosen task vs. assigned task) x 2 (Prime: happiness vs. sadness) between-persons design. All participants were university students. Sixty-four of them were first-year psychology students who participated in exchange for partial course credit, while the remaining 72 participants were recruited through announcements at the University of Geneva and received a remuneration of 10 Swiss Francs (about 10.5 USD) for their participation.

After conducting an initial analysis to verify the data quality and identify any outliers, nine participants were excluded from the study. Three participants were excluded due to ECG or ICG signal loss, one because of extreme PEP responses (> 3 *SD*s than the condition and grand means), one because of extreme SBP reactivity scores (> 3 *SD*s than the condition and grand means), three because of misunderstood task instructions, and one because of prior knowledge of the task manipulations. This resulted in a final sample of N = 127 (mean age 22 years).[1] According to a sensitivity analysis with G*power (Faul et al., 2007), the sample size was sufficient to detect significant a priori contrast and ANOVA main and interaction effects of medium size with 80% power in our 2 × 2 between-persons design.

Affect Primes

Grayscale, low frequency, averaged neutral (MNES - male neutral straight gaze, FNES - female neutral straight gaze), sad (MSAS - male sad straight gaze, FSAS - female sad straight gaze), and happy (MHAS - male happy straight gaze, FHAS - female happy straight gaze) frontal perspective face images (50% male, 50% female faces) from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998) were used as affect primes.

Apparatus and Physiological Measures

We used a Cardioscreen 1000 system (Medis, Ilmenau, Germany) to noninvasively assess HR and PEP based on ECG and ICG signals. Four pairs of electrodes (Ag/AgCl; Medis) were attached on the left and right sides of the participants' neck and chest (left middle axillary line at the height of the xiphoid). The signals were amplified, converted to digital data (sampling rate of 1000 Hz), and analyzed offline (50 Hz low-pass filter). We used BlueBox 2.V1.22 software (Richter, 2010) for the signal processing. The first derivative of the change in thoracic impedance was calculated, and the resulting dZ/dt signal was ensembled over 1-min periods based on the detected R-peaks. B point location was estimated on the basis of the RZ interval of valid cardiac

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[1] The final sample consisted of 95 women and 32 men. The distributions of women and men were balanced across the conditions: Chosen Task/Happiness Primes (24 women, 9 men), Chosen Task/Sadness Primes (25 women, 7 men), Assigned Task/Happiness Primes (22 women, 8 men), and Assigned Task/Sadness Primes (24 women, 8 men). The distributions did not significantly differ between the four conditions according to a chi-square test (p = .96).

cycles (Lozano et al, 2007), visually inspected, and manually corrected if necessary, as recommended (Sherwood et al, 1990). PEP (in ms) was determined as the interval between ECG R onset and the ICG B point (Berntson et al., 2004). Inspections and eventual B-point corrections were made before the main data analysis without knowing the experimental condition or condition *M*s. HR was determined based on the time intervals between heartbeats obtained with the Cardioscreen system.

In addition, SBP and DBP were measured oscillometrically in 1-minute intervals with a Dinamap ProCare monitor (GE Healthcare, Milwaukee, WI). The blood pressure cuff was placed over the brachial artery above the elbow of the participants' nondominant arm. For researchers interested in more detailed hemodynamic responses that were unrelated to our hypotheses, analyses of cardiac output and total peripheral resistance are accessible in the Online Supplemental Material.

Procedure

The experimental procedure and measures were approved by the local ethics committee. To avoid experimenter demand effects (e.g., Gilder & Heerey, 2018), the experimenter was hired and unaware of both the hypotheses and the experimental conditions. After participants had been seated in a comfortable chair and had provided signed consent, the physiological sensors were attached. Participants were then asked if they were wearing a pacemaker or were pregnant.[2] Then, the investigator started the computer program with the experimental procedure (E-Prime 3.0, Psychology Software Tools, Pittsburgh, PA) and went to an adjacent control room. Participants first answered biographical questions (age, gender, etc.) and rated their affective state before exposure

[2] Participants who answered affirmatively to either option, should participate in a “dry” version of the experiment without the ICG/ECG systems installed thus being able to at least obtain their credit. Their data should not be analyzed. However, in the present study, no participants reported to be pregnant or to wear a pacemaker.

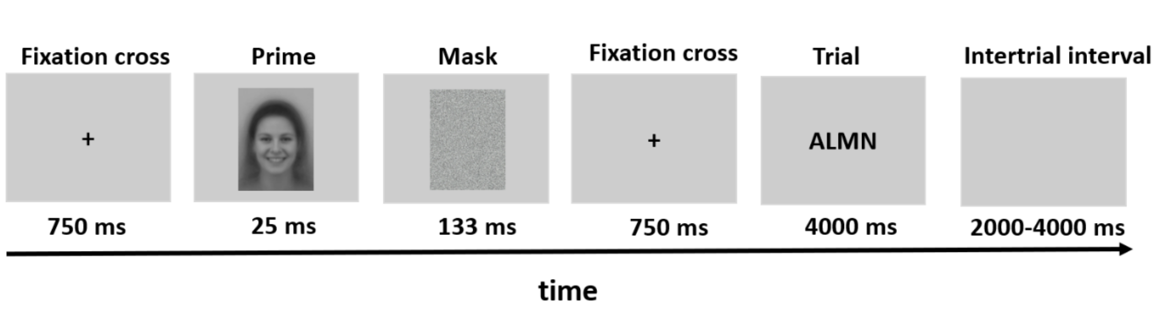
to the affect primes (two sadness items: depressed, sad; two happiness items: happy, joyful) on 7-point scales (1 - *not at all*, 7 - *very much*). To avoid suspicion, these affect measures were introduced as default measures since participants entered the laboratory in different states. Next, participants watched a hedonically neutral documentary about Norway (8 min) to establish baseline cardiovascular values. After the baseline period, participants entered the choice manipulation phase.

Half of the participants were provided with a choice regarding the type of an upcoming cognitive task (Chosen Task condition): They could ostensibly choose between an attention task and a memory task. To provide a reason for their choice, participants read "Recent research shows that the possibility of choosing a task has a positive effect on task performance." The next screen displayed brief descriptions of the two types of tasks: Memory task ("in a memory task, you must remember the stimuli presented") and Attention task ("in an attention task, you must pay attention to the stimuli presented"). Participants were then asked to reflect for 1 minute about the question, "Would you like to work on a memory task or an attention task?" After 1 minute, participants were asked to choose the type of task they wanted to work on by pressing 1 for the memory task and 3 for the attention task. To ensure their commitment, participants were asked to confirm their decision. If they pressed keyboard key “1” for "Yes", the procedure continued. If they pressed keyboard key “3” for "No", they had to indicate their choice again and the procedure continued after they had entered and confirmed their decision.

Participants in the Assigned Task condition received information on the task to perform that was consistent with that given to their yoked participant in the Chosen Task condition. Specifically, if the preceding participant in the Chosen Task condition had chosen the memory task, the next participant in the Assigned Task read: "Current research results show a positive effect on task performance when the cognitive task is a memory task." Likewise, if the yoked participant had chosen the attention task, the participant in the Assigned Task condition read "Current research results show a positive effect on task performance when the cognitive task is an attention task." That way, both the personally chosen and externally assigned tasks had the same ostensibly beneficial effect on task performance. To maintain the conditions as parallel as possible, participants in the Assigned Task condition had a 1-minute break before starting the task.

Next, participants received the task instructions which were identical for everybody except for the headings "Memory Task" versus "Attention Task". The task required detecting and counting vowels in presented series of four letters. This ensured that the task had both continued attention and memorizing components. Importantly, varying only the header guaranteed that participants in the "Memory Task" or "Attention Task" condition were exposed to identical tasks of the same difficulty. Prior to the main task, all participants performed five practice trials to familiarize themselves with the task. At the end of the practice trials, participants were presented with the correct number of vowels that had occurred during the practice trials so that participants could verify the accuracy of the vowels they had counted. During the main task, participants were presented with 36 series of four letters, each consisting of consonants and vowels. Participants who chose or were assigned the memory task received the following instructions: "*Now you are going to do a memory task. The task takes 5 minutes. During the memory task, series of consonants and vowels will be presented to you. Your task is to count and report the exact number of different vowels that are present throughout the 5 minutes. Vowels will not be present in every series. In all, 19 vowels will be presented. After the task, you will be asked to write the number of* *appearances of the vowels A, E, I, O and U that you counted during the experiment on a white sheet that the experimenter will bring you. Try to count all the vowels.*" Participants who chose or were assigned to the attention task were given the same instruction as those in the memory task, except for the words "memory task," which were replaced with "attention task." The 19 vowels appearing in the series were 3 × A; 4 × E; 5 × I; 2 × O; 5 × U. Based on previous studies, the cognitive task was expected to be difficult (Falk et al., 2022a; Framorando & Gendolla, 2019a).

Figure 1. Example of a task trial.



Note. In the example, the letter series "ALMN" is displayed. Participants should memorize the vowel "A".

As depicted in Figure 1, each trial began with a fixation cross (750 ms), followed by an affect prime displayed for 25 ms, and a gray random dot pattern used as a backward mask (133 ms)[3]. Half of the participants were presented with happiness expressions, while the other half were presented with sadness expressions. To avoid habituation effects of the affect primes (Silvestrini & Gendolla, 2011a), they were presented in only 1/3 of the trials, while neutral faces appeared in the remaining trials.

[3] To be consistent with previous studies on affect priming and effort (e.g., Framorando & Gendolla, 2018a, 2018b, 2019a, 2019b, Framorando et al., 2023a, 2023b), primes were presented for 25 ms (3 refresh rates on a 120 Hz screen).

The affect prime presentation was randomized to ensure regular display, with 2 emotional expressions displayed for each set of 6 trials. After each backward mask, another fixation cross appeared (750 ms), followed by the series of 4 letters (4000 ms). The intertrial interval randomly varied between 2000 ms and 4000 ms. After the task, all participants wrote down the number of vowels they had counted (e.g., "A = 3, E = 5, I = 4, O = 4, U = 5") in the presented letter series on a sheet brought to them by the experimenter.

Results

Raw data and data coding are available on Yareta—the open access data archiving server of the University of Geneva: https://doi.org/10.26037/yareta:bdoa3e45ofbe3fgxb6k754gfam. To test our predictions about the moderating effect of personal task choice on the implicit affect's impact on sympathetically mediated cardiovascular response, we used *a priori* contrast analysis, which is the most powerful and therefore most appropriate statistical tool for testing predictions about complex interactions and predicted patterns of means (Rosenthal & Rosnew, 1985; Wilkinson & The Task Force on Statistical Inference of APA, 1999). As outlined above, we expected a 3:1 pattern with weaker sympathetically mediated cardiovascular responses in the Assigned Task/Sadness Primes condition (contrast weight -3) compared with the other 3 conditions (Assigned Task/Happiness Primes; Chosen Task/Sadness Primes; Chosen Task/Happiness Primes; contrast weights + 1). Exploratory ANOVAs were run for variables for which we had no specific theoretical predictions (response accuracy, self-reported anger, fear, and task difficulty).

Cardiovascular Baselines

As in previous studies (e.g., Bouzidi & Gendolla, 2022; Falk et al., 2022a, 2022b; Framorando et al., 2023a, 2023b; Gendolla et al., 2021), we had *a priori* decided to calculate cardiovascular baseline scores by averaging the cardiovascular activity values assessed during the last 3 minutes of the habituation phase—cardiovascular activity typically becomes stable toward the end of the habituation period. The last 3 measures showed high internal consistency (Cronbach's αs ≥ .95).

Preliminary 2 (Choice) x 2 (Prime) ANOVAs of the PEP baseline scores revealed an *a priori* difference between the Prime conditions, $F(1, 123) = 5.54$, $p = .020$, $\eta^2 = .04$. The other effects were non-significant (*ps* > .401). PEP baseline values were higher in the later Sadness Primes conditions (*M* = 100.29, *SE* = 1.15) compared to the later Happiness Primes conditions (*M* = 96.19, *SE* = 1.28). The ANOVAs of the DBP baseline scores revealed a marginally significant main effect of task choice, $F(1, 123) = 3.90$, $p = .050$, $\eta^2 = .03$, in absence of other significant effects (*ps* > .421). Diastolic baseline values tended to be higher in the later Choice condition (*M* = 61.27, *SE* = 0.71) compared to the later Assigned Task condition (*M* = 59.47, *SE* = 0.56). The ANOVAs for the SBP and HR baseline values revealed no significant effects (*ps* > .296)[4].

Given that the prime and choice manipulations were effectuated after the cardiovascular baseline assessment, we can attribute the observed PEP and DBP baseline differences only to chance. However, below we tested with ANCOVAs for significant associations between cardiovascular baseline and reactivity scores in order to prevent possible carryover or initial values effects (Llabre et al., 1991).

[4] The predicted 3:1 *a priori* contrast for cardiovascular reactivity was not significant for any of the cardiovascular baseline values (*ps* ≥ .24). Gender differences in the cardiovascular baselines were also analyzed for interested readers. Gender differences were significant for SBP baseline values, $F(1, 125) = 35.51$, $p < .001$, $\eta^2 = 0.22$.): Baseline values were higher for men (*M* = 114.70, *SE* = 1.30) compared to women (*M* = 105.15, *SE* = .82). Gender differences for the PEP, DBP and HR baseline values were not significant (*ps* ≥ .152).

Table 1. Cell means and standard errors (in parentheses) of cardiovascular baseline scores.

	Chosen Task		**Assigned Task**	
	Happiness Primes	**Sadness Primes**	**Happiness Primes**	**Sadness Primes**
PEP	95.68 (1.69)	101.22 (1.75)	96.74 (1.97)	99.36 (1.51)
SBP	108.62 (1.76)	106.73 (1.61)	107.19 (1.45)	107.64 (1.47)
DBP	60.57 (0.73)	61.99 (1.23)	59.50 (0.81)	59.45 (0.80)
HR	78.44 (2.06)	80.24 (2.02)	78.67 (2.47)	81.47 (2.22)

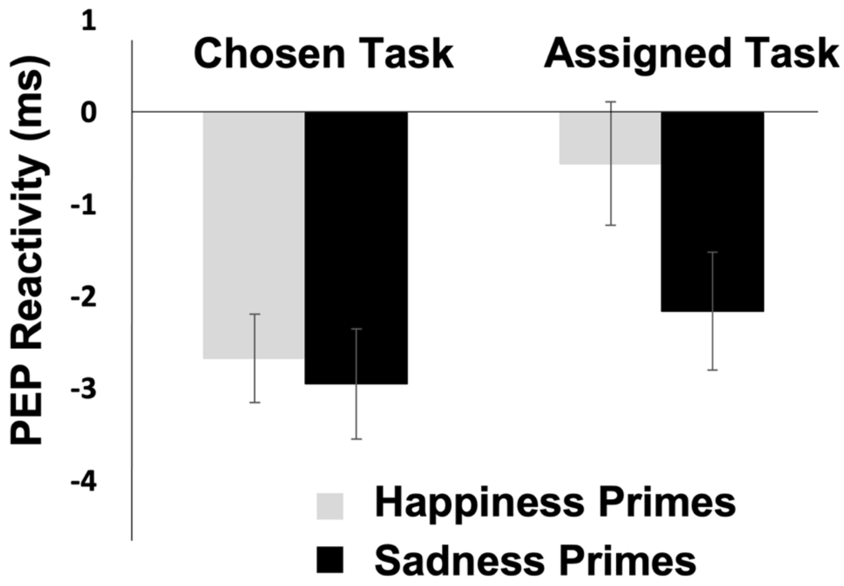
Note: PEP = pre-ejection period (in ms), SBP = systolic blood pressure (in mmHg), DBP = diastolic blood pressure (in mmHg), HR = heart rate (in beats/minute). $N = 127$ for all measures.

Cardiovascular Reactivity

Cardiovascular reactivity scores (Llabre et al., 1991), were created by subtracting the baseline values from the five 1-min values assessed during the task (Cronbach's αs > .88) and averaging these values to task reactivity scores. Preliminary analyses of covariances (ANCOVAs) of the averaged cardiovascular reactivity scores with the respective baseline scores found no significant associations between baseline and reactivity scores for PEP, SBP, and DBP ($ps \geq .129$). However, the covariate effect was significant for HR, $F(1, 122) = 9.36$, $p = .003$, $\eta^2 = .07$. Consequently, we analyzed baseline-adjusted HR reactivity scores.

PEP reactivity. The initial theory-based 3:1 *a priori* contrast for PEP reactivity—our main effort-related cardiovascular measure—was not significant, $F(1, 123) = 0.02$, $p = .884$, $\eta^2 < .01$. However, as depicted in Figure 2, the pattern of PEP reactivity corresponded to what is typical for tasks of unfixed difficulty, in which participants can define their performance standard themselves (e.g., Gendolla & Richter, 2005, 2006; Gendolla et al., 2008). This suggests that participants redefined the task that was intended to be fixed at high difficulty to a "do-your-best" task.

Figure 2. Cell means and ±1 standard errors of PEP reactivity (in ms) in the experimental conditions. Shorter PEP reflects stronger beta-adrenergic sympathetic nervous system impact.



In a task of unfixed difficulty, happiness primes in the Assigned Task condition should lead to lower effort intensity compared to the three other conditions. This is because the happiness primes should render the ease concept accessible, which in turn should result in low subjective demand and thus low effort when task demand is unfixed. In contrast, the sadness primes should make the difficulty concept accessible, resulting in higher subjective task demand and higher effort (e.g., Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011a). In the Chosen Task conditions, the higher commitment resulting from personal task choice should justify high effort and thus lead to relatively high effort if task difficulty is not fixed (Bouzidi et al., 2022) and participants are shielded from the affect prime effects (cf. Falk et al., 2022a)—as predicted by motivational intensity theory (Brehm & Self, 1989). Therefore, we tested our assumption that participants had redefined the fixed difficulty to an unfixed difficulty, "do-your-best" task with the respective contrast modelled according to what is predictable for this task type: A 3:1 reactivity pattern with weaker PEP reactivity in the Assigned Task/Happiness Primes condition than in the other three conditions. This contrast was significant and of medium size for PEP reactivity, $F(1, 123) = 8.34$, $p = .005$, $\eta^2 = .06$. Apparently, although we had originally planned to administer an objectively difficult task, the PEP response patterns corresponded to what can be expected for a task of unfixed difficulty.

In further support of this reactivity pattern, additional follow-up cell contrasts found that the PEP reactivity in the Assigned Task/Happiness Primes condition (M = -0.55, SE = 0.67) was significantly weaker than in the Assigned Task/Sadness Primes Condition, $t(123) = 1.87$, $p = .032$, $\eta^2 = .03$, (M = -2.15, SE = 0.64), the Chosen Task/Sadness Primes Condition, $t(123) = 2.79$, $p = .003$, $\eta^2 = .05$, (M = -2.94, SE = 0.60), and the Chosen Task/Happiness Primes Condition, $t(123) = 2.48$, $p = .007$, $\eta^2 = .05$, (M = -2.66 SE = 0.48).[5] Moreover, the latter three conditions did not significantly differ from one-another, $ts(123) = .94$, $ps > .349$, $\eta^2 < .01$.

Finally, we directly compared the probabilities in favor of the new hypothesis (unfixed difficulty pattern) vs. our original hypothesis (fixed high difficulty pattern) using Bayes statistics (see Masson, 2011). This resulted in a BF of 85.47, implying that the PEP responses are approximately 85 times more likely to support the new hypothesis of an unfixed difficulty pattern than the original hypothesis of a fixed high difficulty pattern.

[5] The *p*-values of focused cell contrasts testing directed predictions are one-tailed.

SBP Reactivity

The original 3:1 *a priori* contrast for a fixed difficult task was not significant for SBP reactivity, $F(1, 123) < 0.01$, $p = .975$, $\eta^2 < .01$. As for PEP, we performed a second 3:1 contrast testing the pattern corresponding to what can be predicted for a task with unfixed difficulty. As for PEP reactivity, this contrast was significant and of medium size, $F(1, 123) = 6.25$, $p = .014$, $\eta^2 = .05$.

As depicted in Table 2, the pattern of SBP was, however, less pronounced than that of the PEP responses reported above. Additional follow-up cell contrasts found that the SBP reactivity in the Assigned Task/Happiness Primes condition ($M = 2.67$, $SE = 0.61$) was marginally significantly weaker than in the Assigned Task/Sadness Primes condition ($M = 4.32$, $SE = 0.66$), $t(123) = 1.56$, $p = .06$, $\eta^2 = .02$, and significantly weaker than the Chosen Task/Sadness Primes condition ($M = 6.05$, $SE = 0.81$), $t(123) = 3.20$, $p = .001$, $\eta^2 = .08$.[6] The Assigned Task/Happiness Primes condition and the Chosen Task/Happiness Primes condition ($M = 4.16$, $SE = 0.83$) did not significantly differ, $t(123) = 1.42$, $p = .079$, $\eta^2 = .02$. Moreover, the latter three cells did not significantly differ from one-another, $ts(123) < 1.83$, $ps \geq .069$, $\eta^2 < .03$.

In addition, as for PEP reactivity, we directly compared the probabilities in favor of our new hypothesis (unfixed difficulty pattern) vs. our original hypothesis (fixed high difficulty pattern) using Bayes statistics (see Masson, 2011) .This resulted in a *BF* of 27.35, implying that the data are approximately 27 times more likely to support the new hypothesis than the original one.

HR and DBP Reactivity

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[6] The *p*-values of focused cell contrasts testing directed predictions are one-tailed.

Neither the original nor the new 3:1 contrasts for the DBP and baseline-adjusted HR reactivity scores were significant, (*ps* ≥ .100). Nevertheless, as depicted in Table 2, the response patterns of both measures strongly corresponded to the unfixed task difficulty based effort pattern.

Table 2. Cell means and standard errors (in parentheses) of DBP and HR reactivity scores.

	Chosen Task		**Assigned Task**	
	Happiness Primes	**Sadness Primes**	**Happiness Primes**	**Sadness Primes**
SBP	4.16 (0.83)	6.05 (0.81)	2.67 (0.61)	4.32 (0.66)
DBP	2.35 (0.66)	2.16 (0.73)	1.27 (0.50)	2.93 (0.54)
HR[a]	2.73 (0.87)	3.49 (0.72)	1.77 (0.71)	2.94 (0.71)

Note: DBP = diastolic blood pressure (in mmHg), HR = heart rate (in beats/minute). *N* = 127 for both measures.
[a] baseline-adjusted.

Task Performance

Participants' task performance was quantified as the total number of vowels that could be detected and correctly recalled (19) minus the number of errors.[7] On average, participants correctly reported 81.35% (*SE* = 1.30) of the vowels. A 2 (Choice) x 2 (Prime) ANOVA revealed neither significant main effects, $Fs(1, 123) > 2.84$, $ps > .09$, $\eta^2 < .03$, nor a significant interaction effect, $F(1, 123) = 0.42$, $p = .521$, $\eta^2 < .01$. Moreover, PEP reactivity during the task tended to be negatively correlated with the number of correctly reported vowels, $r = -.169$, $p = .058$, suggesting a potential link between effort and performance—participants tended to perform better when their PEP became

[7] The number of errors was calculated as the difference between the number of target letters and the correct letters. For example: If a participant indicated the number of target letters to be 1 or 5 when the correct number of target letters was 3, we counted such responses as 2 errors.

shorter during the task. Correspondingly, also the responses of SBP, $r = .161$, $p = .071$, and DBP, $r = .170$, $p = .056$, tended to be correlated with task performance. The link between HR reactivity and the performance scores was not significant and weaker, $r = .068$, $p = .449$.

Verbal Measures

Choice manipulation check. A 2 (Choice) x 2 (Prime) ANOVA of the verbal choice manipulation check revealed a strong significant Choice main effect indicating the high efficiency of our choice manipulation, $F(1, 123) = 80.57$, $p < .001$, $\eta^2 = .40$. Participants in the Chosen Task condition ($M = 67.51$, $SE = 3.11$) rated their freedom to choose the task as significantly higher than those in the Assigned Task condition ($M = 26.44$, $SE = 3.35$). No other effects were significant (*p*s > .351).

Experienced affect. We created sadness and happiness sum scores for participants' pre-task (*r*s ≥ .57, *p*s <. 001) and post-task (*r*s ≥ .63, *p*s < .001) happiness and sadness ratings. A 2 (Choice) x 2 (Prime) x 2 (Time) mixed-model ANOVA of the sadness scores revealed a Time main effect, $F(1, 123) = 7.49$, $p = .007$, $\eta^2 = .06$, reflecting lower sadness scores before ($M = 48.43$, $SE = 3.49$) than after the task ($M = 56.95$, $SE = 3.60$). No other effect was significant (*ps* > .519). A 2 (Choice) x 2 (Prime) x 2 (Time) mixed-model ANOVA of the happiness scores revealed a Time main effect, $F(1, 123) = 23.28$, $p < .001$, $\eta^2 = .16$, reflecting higher happiness ratings before ($M = 125.92$, $SE = 3.27$) than after the task ($M = 111.77$, $SE = 3.21$). No other effect was significant (*ps* > .436).

We also ran additional ANCOVAs of PEP and SBP reactivity with the post-task affect ratings as covariates, which revealed no significant associations between PEP and SBP reactivity and the sadness or happiness scores, *Fs* < 0.83, *ps* > .364, $\eta^2 < .01$. In addition, the contrasts of PEP and SBP reactivity remained significant, *Fs* > 6.35, *ps* > .013, $\eta^2 > .04$, after controlling for rated sadness or happiness as covariates. This does not speak for the possibility that the affect primes triggered conscious feelings that in turn influenced PEP or SBP reactivity.

Task difficulty. A 2 (Choice) × 2 (Prime) ANOVA on participants' post task difficulty ratings found no significant effects, *Fs*(1, 123) < 1.37, *ps* > .245, $\eta^2 < .02$, (*M* = 62.78, *SE* = 1.90).

Funnel Debriefing

No participant correctly guessed the purpose of the present study in the funnel debriefing. Only 6 participants (i.e., 4.7 %) reported having seen the masked emotional expressions faces that were presented in their condition, suggesting that a vast majority of participants (95.3%) might have processed the affect primes without awareness, as intended. Among the few participants who could correctly identify the facial expressions, there were three (2.35 %) in the Chosen Task condition and 3 (2.35 %) in the Assigned Task condition.

Discussion

The present experiment provides additional empirical support for the action shielding model (Gendolla et al., 2021)—especially for the moderating role of personal task choice of implicit happiness primes' effect on sympathetically mediated cardiovascular responses during task performance which reflect effort. This is an important extension of the already existing evidence for action-choice based shielding against explicit incidental affective influences like pleasant and unpleasant music (Falk et al., 2002a, 2022b), aversive noise (Falk et al., 2023), and, most important, implicitly processed conflict (Bouzidi & Gendolla, 2023a, 2023b) as well as fear and anger primes (Framorando et al., 2023a, 2023b).

Although we wanted to administer an objectively difficult task, the PEP and SBP response patterns corresponded to what can be expected for a task of unfixed difficulty. In tasks of unfixed difficulty, participants do their best rather than trying to attain a fixed difficult performance standard: PEP and SBP responses in the Assigned Task/Happiness Primes condition were weaker than in the other three conditions. Importantly, the effect of the happiness and sadness primes in the Assigned Task condition was predicted and found in previous studies with tasks of unfixed difficulty (when participants were instructed to do their best rather than attain a fixed high performance standard; e.g., Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011a, 2011b). Moreover, the relatively strong sympathetically mediated cardiovascular reactivity in both affect prime conditions when participants could personally choose their task corresponds with what was earlier predicted and found when participants tried to do their best under so-called self-relevant performance conditions that render the importance of success relatively high and thus justify high effort (e.g., Gendolla & Richter, 2005, 2006; Gendolla et al., 2008). Most relevant, this was recently also found when participants could personally choose characteristics of a task with unspecified difficulty (Bouzidi et al., 2022). That is, although we originally aimed at letting participants work on a task of fixed high difficulty, they apparently redefined the task. Instead of trying to attain a fixed difficult performance standard, they tried to do their best. The resulting PEP and SBP reactivity patterns, observed in the present study, are in line with this idea.

We think that the task instructions in our present study made it possible for the participants to easily redefine the task to a challenge of unfixed difficulty. The instructions informed about the total number of letters to be presented but did not specify the exact number of letters to be recalled for succeeding the task. That is, there was some unintended ambiguity about the success criterion, which created a task context that allowed participants to try to do their best—or in other words, to self-define a vague performance goal (Locke & Latham, 1990, 2019). The exact number of vowels to be recalled was not specified on purpose. The task instructions were created to be plausible for both an attention and a memory task. Specifying the number of letters would have put too much weight to the memory aspect of the task, rendering the task choice manipulation less plausible. However, also unintended, this facilitated "doing one's best" instead of trying to attain a fixed high success criterion. The observed responses of PEP and SBP during task performance correspond to this interpretation.

Cardiovascular Effects

On the physiological level, the strongest effects occurred on PEP reactivity, our primary effort-related measure. This was anticipated, as PEP is the most sensitive indicator of beta-adrenergic sympathetic impact on the heart (Kelsey, 2012; Wright, 1996). The effects on SBP were also significant, which is not unusual because cardiac contractile force systematically influences SBP through its impact on cardiac output. Accordingly, numerous studies have operationalized effort using SBP reactivity (see Gendolla et al., 2012, 2019; Richter et al., 2016; Wright & Kirby, 2001, for overviews). However, SBP and, to an even greater extent, DBP are affected not only by beta-adrenergic sympathetic impact on the heart but also by peripheral vascular resistance, rendering SBP and DBP responses less reliable effort indices compared to PEP. Therefore, effort effects on SBP are less likely and DBP effects are improbable. This explains why in the present research the effects on SBP reactivity were less pronounced as those on PEP, as evident in the partly nonsignificant cell comparisons (see also

Richter et al., 2008). However, previous studies that directly investigated the effects of sadness and happiness primes in assigned tasks with "do your best" instructions also found effects on SBP reactivity (e.g., Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011a).

In addition, the responses of PEP in our study were not associated with a decrease in diastolic blood pressure or HR. Importantly, increases in cardiac preload (ventricular filling) increase the force of myocardial contraction via the Frank-Starling mechanism and thus shorten PEP. By contrast, increases in cardiac afterload (aortic diastolic pressure) prolong PEP due to increases in peripheral resistance, because it takes longer to build up the necessary force to open the aortic valves. Our findings speak against the attribution of the observed PEP responses to cardiac preload or vascular afterload effects and thus provide evidence for a beta-adrenergic influence sympathetic nervous system effect.

Performance and Self-Report Measures

In contrast to the effects observed on PEP and SBP reactivity, there were no significant manipulation outcomes on our task performance measure. This is, however, not surprising, because we did not expect that variations in effort would be automatically associated with variations on performance. Some of our previous studies found affect prime effects on performance (e.g., Framorando & Gendolla, 2018a, 2023; Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013)—but many others did not. Similar to the present experiment, those studies were designed for testing implicit affect effects on physiological measures, which calls for between-persons designs. Performance effects are usually investigated in within-persons designs to control for large individual differences in cognitive processing. It is also of note that effort intensity (behavioral input) and performance (behavioral output) are not identical, and that performance depends not only on effort but also, or even more strongly, on persistence, task-related capacities, and applied strategies (Locke & Latham, 1990). This is especially relevant for the task we have administered in which many different strategies could be used to influence memory performance.

Regarding our self-report measures, participants in the Chosen Task condition rated their freedom to choose the task as significantly higher than those in the Assigned Task condition, showing that the task choice manipulation had a strong effect on participants' experience to have control over the type of task they engaged in. Moreover, no participant expressed any doubts about our choice manipulation during the debriefing. Thus, our choice manipulation worked as intended.

The present study found no evidence that the administered affect primes had effects on measures of conscious affect, which aligns with previous research on implicit affective influences on effort (see Gendolla, 2015; Silvestrini & Gendolla, 2019, for reviews). Although the absence of significant effects does not allow for firm conclusions, the lack of evidence for prime effects on consciously experienced affect is in line with the IAPE model idea that affect primes influence resource mobilization implicitly without effects on conscious affective experiences. It is noteworthy that during the debriefing, only 4.7% of the 127 participants correctly reported to have seen the emotional faces during the task. This suggests that 95.3% of the participants were unaware of the priming stimuli, indicating that the affective influences in the present study were as intended implicit. Accordingly, personal task choice seems indeed to shield against implicit influences on action execution, which is an important finding.

Implications for the Affect-Effort Link

So far, research on the action shielding model has primarily focused on conscious affective influences (Falk et al., 2022a, 2022b; Gendolla et al., 2021) rather than implicit affective influences on effort. Besides compatible research on shielding effects against primed cognitive conflict (Bouzidi & Gendolla, 2023a, 2023b), there are to date only two other studies finding that personal task choice attenuates the effects of implicitly processed emotional stimuli on effort-related cardiovascular response. There, personal task choice shielded against the effect of fear and anger primes on effort in a moderately difficult task (Framorando et al., 2023a), and against the effects of sadness and anger primes in an objectively difficult task (Framorando et al., 2023b). Importantly, our present study conceptually replicated these findings with different types of implicit affect in a different task context—a task with unfixed difficulty. Thus, our findings lend additional support to the action shielding model (Gendolla et al., 2021).

Finally, the present research has significant implications for the understanding of the conditions that are necessary for implicit affective influences on action execution. Research on the IAPE model (Gendolla, 2012, 2015) recently identified boundary conditions for affect primes' effects on effort. Specifically, affect primes influenced sympathetically mediated cardiovascular responses only if individuals were (1) not aware of being primed (Framorando & Gendolla, 2018a, 2018b, 2019b; Lasauskaite Schüpbach et al., 2014), (2) if the primes were processed in an achievement task context (Framorando & Gendolla, 2019a), and (3) if the primes did not appear too frequently (Silvestrini & Gendolla, 2011a). Our present study contributes to this line of research by showing that engaging in a task by personal choice is an additional boundary condition for incidental implicit affective influences on effort.

Conclusions

The present experiment lends further support to the action shielding model (Gendolla et al., 2021) and the important role of personal choice in human action control (Bandura, 1986, 2001; Deci & Ryan, 2006, Deci et al., 2022). It contributes to the understanding of moderators and boundary conditions of automaticity in effort exertion. Accordingly, personally choosing one's tasks activates a mental state that protects action execution from incidental affective influences. Notably, personal task choice can even shield against implicit affect primes' effects on effort-related cardiovascular responses. This is a robust new illustration of the power of personal choice in action control.

References

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* New Jersey: Prentice Hall.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52,* 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

Berntson, G. G., Lozano, D. L., Chen, Y.-J., & Cacioppo, J. T. (2004). Where to Q in PEP. *Psychophysiology, 41*, 333–337. https://doi.org/10.1111/j.1469-8986.2004.00156.x.

Bouzidi, Y.S., Falk, J.R., Chanal, J., & Gendolla, G. H. E. (2022). Choosing task characteristics oneself justifies effort: A study on cardiac response and the critical role of task difficulty. *Motivation Science, 8*(3), 230–238. https://doi.org/10.1037/mot0000269

Bouzidi, Y. S., & Gendolla, G. H. E. (2023a). Is cognitive conflict really effortful? Conflict priming and shielding effects on cardiac response. *Psychophysiology*, *60*: e14238. https://doi.org/10.1111/psyp.14169

Bouzidi, Y.S., & Gendolla, G.H.E. (2023b). Action-orientation shields against primed cognitive conflict effects on effort-related cardiac response. *Psychophysiology*, *60*: e14407. https://doi.org/10.1111/psyp.14407

Brehm, J. W., & Self, E. A. (1989). The intensity of motivation. *Annual Review of Psychology, 40*, 109–131. https://doi.org/10.1146/annurev.ps.40.020189.000545

Chatelain, M., & Gendolla, G. H. E. (2015). Implicit fear and effort-related cardiac response. *Biological Psychology*, *111*, 73–82. doi: https://doi.org/10.1016/j.biopsycho.2015.08.009

Chatelain, M., & Gendolla, G. H. E. (2016). Monetary incentive moderates the effect of implicit fear on effort-related cardiovascular response. *Biological Psychology*, *117*, 150–158. doi: 10.1016/j.biopsycho.2016.03.014

Chatelain, M., Silvestrini, N., & Gendolla, G. H. E. (2016). Task difficulty moderates implicit fear and anger effects on effort-related cardiac response. *Biological Psychology*, *115*, 94–100. doi: 10.1016/j.biopsycho.2016.01.01

Elliott, R. (1969). Tonic heart rate: Experiments on the effects of collative variables lead to a hypothesis about its motivational significance. *Journal of Personality and Social Psychology, 12*, 211–228. https://doi.org/10.1037/h0027630

Eubanks, L., Wright, R. A., & Williams, B. J. (2002). Reward influence on the heart: Cardiovascular response as a function of incentive value at five levels of task demand. *Motivation and Emotion*, *26*, 139–152. https://doi.org/10.1023/A:1019863318803

Falk, J. R., Gollwitzer, P. M., Oettingen, G., & Gendolla, G. H. E. (2022a). Task choice shields against incidental affective influences on effort-related cardiovascular response. *Psychophysiology*, e14022. https://doi.org/10.1111/psyp.14022

Falk, J. R., Gollwitzer, P. M., Oettingen, G., & Gendolla, G. H. E. (2022b). Incidental affective influences on effort-related cardiac response: The critical role of choosing task characteristics. *International Journal of Psychophysiology*, *177*, 76–82. https://doi.org/10.1016/j.ijpsycho.2022.04.010

Falk, J. R., Gollwitzer, P. M., Oettingen, G., & Gendolla, G. H. E. (2023). Noise annoys—but personal choice can attenuate noise effects on cardiac response reflecting effort. *Psychophysiology.* https://doi.org/10.1111/PSYP.14502

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191. https://doi.org/10.3758/bf03193146.

Förster, J., & Liberman, I. (2007). Knowledge activation. In A. W. Kruglanksi & E. T. Higgins (Eds.), *Social psychology: Handbook of basic principles* (2nd ed., pp. 201–231). New York, NY: Guilford.

Framorando, D., Falk, J. R., Gollwitzer, P. M., Oettingen, G., & Gendolla, G. H. E. (2023a). Can personal task choice shield against fear and anger prime effects on effort? A study on cardiac response. *Biological Psychology*, *181,* 108616. https://doi. org/ j.biopsycho.2023.108616

Framorando, D., Falk, J. R., Gollwitzer, P. M., Oettingen, G., & Gendolla, G. H. E. (2023b). The power of personal control: Task choice immunizes against implicit affective influences on effort-related cardiac response. *Psychophysiology, in press.* https://doi. org/ 10.1111/PSYP.14495

Framorando, D., & Gendolla, G. H. E. (2018a). Prime visibility moderates implicit anger and sadness effects on effort-related cardiac response. *Biological Psychology, 135*, 204–210. https://doi. org/10.1016/j.biopsycho.2018.04.007

Framorando, D., & Gendolla, G. H. E. (2018b). The effect of negative implicit affect, prime visibility, and gender on effort-related cardiac response. *Adaptive Human Behavior and Physiology, 4*(4), 354-363. https://doi.org/10.1007/s40750-018-0097-0

Framorando, D., & Gendolla, G. H. E. (2019a). It's about effort: Impact of implicit affect on cardiovascular response is context dependent. *Psychophysiology, 56*: e13436. https://doi.org/10.1111/psyp.13436

Framorando, D., & Gendolla, G. H. E. (2019b). Prime warning moderates implicit affect primes' effect on effort-related cardiac response in men. *Biological Psychology, 142*, 62–69. https://doi.org/10.1016/j. biopsycho.2019.01.013

Framorando, D. & Gendolla, G. H. E. (2023). Fear and anger prime effects on cognitive performance: The role of prime visibility. *Swiss Psychology Open, 3*(1), 10. https://doi.org/10.5334/spo.33

Freydefont, L., & Gendolla, G. H. E. (2012). Incentive moderates the impact of implicit anger versus sadness cues on effort-relate cardiac response. *Biological Psychology*, *91*, 120–127. doi: 10.1016/j.biopsycho.2012.04.002.

Freydefont, L., Gendolla, G. H. E., & Silvestrini, N. (2012). Beyond valence: the differential effect of masked anger and sadness stimuli on effort-related cardiac response. *Psychophysiology, 49,* 665–671. doi: 10.1111/j.1469-8986.2011.01340.x

Gendolla, G. H. E. (2012). Implicit affect primes effort: A theory and research on cardiovascular response. *International Journal of Psychophysiology, 86*(2), 123–135. https://doi.org/10.1016/j.ijpsycho.2012.05.003

Gendolla, G. H. E. (2015). Implicit affect primes effort: Basic processes, moderators, and boundary conditions. *Social and Personality Psychology Compass*, *9*(11), 606–619. https://doi.org/10.1111/spc3.12208

Gendolla, G. H. E., Bouzidi, Y. S., Arvaniti, S., Gollwitzer, P. M., & Oettingen, G. (2021). Task choice immunizes against incidental affective influences in volition. *Motivation Science, 7*(3), 229–241. https://doi.org/10.1037/mot0000225

Gendolla, G. H. E., & Richter, M. (2005). Ego-involvement and mental effort: Cardiovascular, electrodermal, and performance effects. *Psychophysiology, 42,* 595–603. https://doi.org/10.1111/j.1469-8986.2005.00314.x

Gendolla, G. H. E., & Richter, M. (2006). Ego-involvement and the difficulty law of motivation: Effects on performance-related cardiovascular response. *Personality and Social Psychology Bulletin*, *32*(9), 1188–1203. https://doi.org/10.1177/0146167206288945

Gendolla, G. H. E., Richter, M., & Silvia, P. (2008). Self-focus and task difficulty effects on effort-related cardiovascular reactivity. *Psychophysiology, 45,* 653–662. https://doi.org/10.1111/j.1469-8986.2008.00655.x

Gendolla, G. H. E., & Silvestrini, N. (2011). Smiles make it easier and so do frowns: masked affective stimuli influence mental effort. *Emotion, 11*(2), 320. https ://doi.org/10.1037/a0022593

Gendolla, G. H. E., & Wright, R. A. (2009). Effort. In D. Sander & K. R. Scherer (Eds.), *The Oxford companion to emotion and the affective science* (pp. 134–135). Oxford University Press.

Gendolla, G. H. E., & Richter, M. (2010). Effort mobilization when the self is involved: Some lessons from the cardiovascular system. *Review of General Psychology, 14*(3), 212–226. https://doi.org/10.1037/a0019742

Gendolla, G. H. E., Wright, R. A., & Richter, M. (2012). Effort intensity: Some insights from the cardiovascular system. In R. M. Ryan (Ed.), *The Oxford Handbook of Human Motivation* (pp. 420–439). Oxford University Press.

Gendolla, G. H. E., Wright, R. A., & Richter, M. (2019). Advancing issues in motivation intensity research: Updated insights from the cardiovascular system. In R. M. Ryan (Ed.), *The Oxford handbook of human motivation* (pp. 372–392). New York, NY: Oxford University Press. https://doi.org/10.1093/oxfor dhb/9780190666453.013.21

Gilder, T. S. E., & Heerey, E. A. (2018). The role of experimenter belief in social priming. *Psychological Science, 29*(3), 403–417. https://doi.org/10.1177/0956797617737128

Gollwitzer, P. M. (1990). Action phases and mind-sets. In E. T. Higgins & R. M. Sorrentino (Eds.), *Handbook of motivation and cognition: Foundations of social behavior* (pp. 53–92). Guilford.

Heckhausen, H., & Gollwitzer, P. M. (1987). Thought contents and cognitive functioning in motivational versus volitional states of mind. *Motivation and Emotion, 11*(2), 101–120. https://doi.org/10.1007/BF00992338

Kelsey, R. M. (2012). Beta-adrenergic cardiovascular reactivity and adaptation to stress: The cardiac pre-ejection period as an index of effort. In R. A. Wright & G. H. E. Gendolla (Eds.), *How motivation affects cardiovascular response: Mechanisms and applications* (pp. 43–60). Washington, DC: American Psychological Association.

Kuhl, J. (1986). Motivation and information processing. A new look at decision making, dynamic change, and action control. In E. T. Higgins & R. M. Sorrentino (Eds.), *Handbook of cognition and emotion: Foundations of social behavior* (Vol. 2, pp. 527–561). Guilford.

Lasauskaite, R., Gendolla, G. H. E., Bolmont, M., & Freydefont, L. (2017). Implicit happiness and sadness are associated with ease and difficulty: Evidence from sequential priming. *Psychological Research, 81,* 321–331. doi: 10.1007/s00426-015-0732-3

Lasauskaite, R., Gendolla, G. H. E., & Silvestrini, N. (2013). Do sadness primes make me work harder, because they make me sad? *Cognition and Emotion, 27,* 158–165. doi: 10.1080/02699931.2012.689756

Lasauskaite Schüpbach, R., Gendolla, G. H. E., & Silvestrini, N. (2014). Contrasting the effects of suboptimally versus optimally presented affect primes on effort-related cardiac response. *Motivation and Emotion, 38*, 748–758. doi: 10.1007/s11031-014-9438-x

Leotti, L. A., Iyengar, S. S., & Ochsner, K. N. (2010). Born to choose: The origins and value of the need for control. *Trends in Cognitive Sciences*, *14*, 457–463. https://doi.org/10.1016/j.tics.2010.08.001

Levick, J. R. (2003). *Introduction to cardiovascular physiology* (4th ed). New York: Oxford University Press.

Llabre, M. M., Spitzer, S. B., Saab, P. G., Ironson, G. H., & Schneiderman, N. (1991). The reliability and specificity of delta versus residualized change as measure of cardiovascular reactivity to behavioral challenges. *Psychophysiology, 28*, 701–711. https://doi.org/10.1111/j.1469-8986.1991.tb01017.x.

Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting and task performance*. Prentice-Hall, Inc.

Locke, E. A., & Latham, G. P. (2019). The development of goal setting theory: A half century retrospective. *Motivation Science,* 93–105. https://doi.org/10.1037/mot0000127

Lozano, D. L., Norman, G., Knox, D., Wood, B. L., Miller, D., Emery, C. F., & Berntson, G. G. (2007). Where to B in dZ/dt. *Psychophysiology, 44*, 113–119. https://doi.org/10.1111/j.1469-8986.2006.00468.x

Lundqvist, D., & Litton, J. E. (1998). *The averaged Karolinska directed emotional faces*. Stockholm: Karolinska Institute, Department of Clinical Neuroscience, Section Psychology.

Masson, M. E. (2011). A tutorial on a practical Bayesian alternative to null-hypothesis significance testing. *Behavior Research Methods*, *43*, 679–690. https://doi.org/10.3758/s13428-010-0049-5

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibition less spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General, 106*, 226–254. https://doi.org/10.1037/0096-3445.106.3.226

Nenkov, G. Y., & Gollwitzer, P. M. (2012). Pre-versus postdecisional deliberation and goal commitment: The positive effects of defensiveness. *Journal of Experimental Social Psychology, 48*(1), 106–121. https://doi.org/10.1016/j.jesp.2011.08.002

Obrist, P. A. (1981). *Cardiovascular psychophysiology: A perspective*. New York, NY: Plenum Press. https://doi.org/10.1007/ 978-1-4684-8491-5

Patall, E. A. (2012). The motivational complexity of choosing: A review of theory and research. In R. M. Ryan (Ed.), *The Oxford handbook of human motivation* (pp. 248–279). Oxford University Press.

Patall, E. A. (2019). The complex role of choice in human motivation and functioning. In R. M. Ryan (Ed.), *The Oxford handbook of human motivation* (2nd ed.) (pp. 135–155). Oxford University Press.

Patall, E. A., Cooper, H., & Robinson, J. C. (2008). The effects of choice on intrinsic motivation and related outcomes: a meta-analysis of research findings. *Psychological Bulletin, 134*, 270–300. https://doi.org/10.1037/0033-2909.134.2.270

Richter, M. (2010). *BlueBox 2 v1.22*. University of Geneva.

Richter, M., Gendolla, G. H. E., & Wright, R. A. (2016). Three decades of research on motivational intensity theory: What we have learned about effort and what we still don't know. *Advances in Motivation Science, 3*, 149–186. https://doi.org/10.1016/bs.adms.2016.02.001

Rosenthal, R., & Rosnow, R. L. (1985). *Contrast analysis*. Cambridge University Press.

Ryan, R. M., & Deci, E. L. (2006). Self-regulation and the problem of human autonomy: Does psychology need choice, self-determination, and will? *Journal of Personality*, *74*(6), 1557–1586. https://doi.org/10.1111/j.1467-6494.2006.00420.x

Ryan, R. M., Deci, E. L., Vansteenkiste, M., & Soenens, B. (2021). Building a science of motivated persons: Self-determination theory's empirical approach to human experience and the regulation of behavior. *Motivation Science, 7*, 97–110. https://doi.org/10.1037/mot0000194

Shah, J. Y., Friedman, R., & Kruglanski, A. W. (2002). Forgetting all else: On the antecedents and consequences of goal shielding. *Journal of Personality and Social Psychology, 83*(6), 1261–1280. https://doi.org/10.1037//0022-3514.83.6.1261

Sherwood, A., Allen, M. T., Fahrenberg, J., Kelsey, R. M., Lovallo, W. R., & Doornen, L. J. P. (1990). Methodological guidelines for impedance cardiography. *Psychophysiology, 27*, 1–23. https://doi. org/10.1111/j.1469-8986.1990.tb02171.x

Silvestrini, N., & Gendolla, G. H. E. (2011a). Do not prime too much: Prime frequency effects of masked affective stimuli on effort-related cardiovascular response. *Biological Psychology, 87*, 195–199. https://doi.org/10.1016/j.biopsycho.2011.01.006

Silvestrini, N., & Gendolla, G. H. E. (2011b). Masked affective stimuli moderate task difficulty effects on effort-related cardiovascular response. *Psychophysiology, 48*(8), 1157–1164. https://doi.org/10.1111/j.1469-8986.2011.01181.x

Silvestrini, N., & Gendolla, G. H. E. (2019). Affect and cognitive control: Insights from research on effort mobilization. *International Journal of Psychophysiology, 143*, 116–125. https://doi.org/10.1016/j.ijpsycho.2019.07.003

Wilkinson, L. A., & The Task Force on Statistical Inference of APA. (1999). Statistical methods in psychology journals. *American Psychologist*, *54*, 594–604. sshttps://doi.org/10.1037/0003-066X.54.8.594

Wright, R. A. (1996). Brehm's theory of motivation as a model of effort and cardiovascular response. In P. M. Gollwitzer & J. A. Bargh (Eds.), *The psychology of action: Linking cognition and motivation to behavior* (pp. 424–453). Guilford.

Wright, R. A., & Kirby, L. D. (2001). Effort determination of cardiovascular response: An integrative analysis with applications in social psychology. *Advances in Experimental Social Psychology, 33*, 255–307. https://doi.org/10.1016/S0065-2601(01)80007-1

Highlights

- Participants could choose or were assigned to a cognitive task
- Briefly flashed happiness vs. sadness primes were presented during the task
- When the task was assigned, sadness primes led to stronger cardiac PEP reactivity than happiness primes
- This priming effect was no longer observed when participants could personally choose their task

Supplemental Material

Cardiac output (CO) and total peripheral resistance (TPR) were also analyzed to provide interested readers with a more comprehensive picture of the hemodynamic response during task performance, although neither measure was relevant for our hypotheses. Two participants were excluded from the CO and TPR analyses (one for each measure) because of excessive CO or TPR reactivity (> 3 *SD*s than condition and grand means). CO was calculated by the Cardioscreen system according to the Sramek and Bernstein formula (see Bernstein, 1986). TPR was derived from CO and mean arterial pressure (MAP = 2 x DBP + SBP / 3) according to the formula TPR = (MAP / CO) * 80 (Sherwood et al., 1990). Given the absence of specific hypotheses for the two hemodynamic indices, both CO and TPR were analyzed with 2 (Choice) x 2 (Prime) ANOVAs.

CO and TPR Baseline Values

CO and TPR values were constituted by averaging the cardiovascular values of the last three minutes of the habituation phase (Cronbach's αs > .99). The mean values and standard errors of the cells are presented in Supplemental Table S1. Preliminary 2 (Choice) x 2 (Primes) ANOVAs of the baseline scores revealed no significant effects (*ps* > 0.146).[8]

[8] The 3:1 contrast with which we tested the pattern cardiovascular reactivity pattern in an unfixed task context was not significant (*ps* ≥ .333) for the baseline values of CO and TPR. For readers interested in gender differences, we also compared the cardiovascular baseline values of women and men, which did reveal a marginally significant difference for baseline values of CO, $F(1, 124) = 3.73$, $p = .056$, $\eta^2 = 0.03$. Men tend to have higher baseline values of CO (*M* = 6.25; *SE* = 0.26) than women (*M* = 5.79; *SE* = 0.11). The effect of gender was not significant for the baseline values of TPR ($p = .894$).

Supplemental Table S1

Means and Standard Errors (in Parentheses) of Baseline Values of Cardiac Output and Total Peripheral Resistance.

	Chosen Task		**Assigned Task**	
	Happiness Primes	**Sadness Primes**	**Happiness Primes**	**Sadness Primes**
CO	5.77 (0.21)	6.04 (0.25)	5.72 (0.18)	6.07 (0.19)
TPR	1079.54 (31.57)	1048.74 (31.82)	1184.30 (38.13)	1029.37 (37.91)

Note: CO = cardiac output (in liters per minute), TPR = total peripheral resistance (in dynes second per centimeter to the 5th power). *N* = 126 for both measures.

CO and TPR Reactivity

Reactivity scores of CO and TPR were created by subtracting the baseline values from the five 1-min values assessed during the task (Cronbach's αs > .87). Means and standard errors are shown in Supplemental Table S2.

Supplemental Table S2

Means and Standard Errors (in Parentheses) of Cardiac Output and Total Peripheral Resistance Reactivity.

	Chosen Task		**Assigned Task**	
	Happiness Primes	**Sadness Primes**	**Happiness Primes**	**Sadness Primes**
CO	0.20 (.06)	0.15(0.53)	0.03 (0.06)	0.17 (0.04)
TPR	9.64 (8.59)	13.28 (9.75)	17.91 (11.64)	17.83 (8.59)

Note: CO = cardiac output (in liters per minute), TPR = total peripheral resistance (in dynes second per centimeter to the 5^{th} power). *N* = 126 for both measures.

CO Reactivity. A 2 (Choice) × 2 (Prime) ANOVA of CO reactivity revealed neither significant main effects nor an interaction effect (*ps* ≥ 0.091). However, descriptively, the CO reactivity pattern corresponded to the 3:1 pattern for an unfixed difficulty task. As presented in Supplemental Table S2, Happiness Primes produced weaker CO responses in the Assigned Task condition compared to the Assigned Task/Sadness Primes condition, the Chosen Task/Happiness Primes condition, and the Chosen Task/Sadness Primes condition. The respective 3:1 contrast was significant, $F(1, 122) = 4.91$, $p = 0.029$, $\eta^2 = .04$. Additional follow-up cell contrasts found that the CO reactivity in the Assigned Task/Happiness Primes condition ($M = 0.03$, $SE = 0.06$) was significantly weaker than in the Chosen Task/Happiness Primes condition ($M = 0.20$, $SE = 0.06$), $t(123) = 2.20$, $p = 0.03$, $\eta^2 = .04$. All other cell mean did not significantly differ from one-another, $ts(123) < 1.75$, $ps \geq 0.084$, $\eta^2 < .03$.

In addition, we directly compared the probabilities in favor of the new hypothesis (unfixed difficulty pattern) vs. our original (fixed high difficulty pattern) using Bayes statistics (see Masson, 2011). This resulted in a *BF* of 7.88, implying that the data are approximately 7 times more likely to support the new hypothesis than the original one.

TPR Reactivity. According to a 2 (Choice) × 2 (Prime) ANOVA of TPR reactivity, there were no significant effects (*ps* > 0.509). The 3:1 a priori effort contrast for an unfixed difficulty task was also not significant ($p = 0.704$).

Supplemental References

Bernstein, D. P. (1986). A new stroke volume equation for thoracic electrical bioimpedance: Theory and rationale. *Critical Care Medicine, 14*, 904-909. https://doi.org/10.1097/00003246-198610000-00017

Masson, M. E. (2011). A tutorial on a practical Bayesian alternative to null-hypothesis significance testing. *Behavior Research Methods*, *43*, 679-690. https://doi.org/10.3758/s13428-010-0049-5

Sherwood, A., Allen, M. T., Fahrenberg, J., Kelsey, R. M., Lovallo, W. R., & Doornen, L. J. P. (1990). Methodological guidelines for impedance cardiography. *Psychophysiology, 7*, 1–23. https://doi.org/10.1111/j.1469-8986.1990.tb02171.x