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Can personal task choice shield against fear and anger prime effects on effort? A study on cardiac response☆

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ABSTRACT

This experiment tested whether personal task choice can shield against implicit affective influences on sympathetically mediated cardiovascular response, reflecting effort. Participants were $N = 121$ healthy university students who completed a moderately difficult memory task with integrated briefly flashed and masked fear vs. anger primes. Half of the participants believed they could choose between an attention and a memory task, while the other half was automatically assigned to the task. Replicating previous research, we expected an influence of the affect primes on effort when the task was externally assigned. By contrast, when participants were given a task choice, we predicted strong action shielding and thus a weak implicit affect effect on resource mobilization. As expected, participants in the assigned task condition showed stronger cardiac pre-ejection period reactivity when exposed to fear primes than when processing anger primes. Importantly, this affect prime effect disappeared when participants could ostensibly choose the task. These findings add to other recent evidence for action shielding by personal task choice and importantly extend this effect to implicit affective influences on cardiac reactivity during task performance.

1. Introduction

Research on the Implicit-Affect-Primes-Effort (IAPE) model (Gendolla, 2012) has revealed replicated evidence for systematic implicit affective influences on cardiovascular responses during cognitive tasks (e.g., Chatelain & Gendolla, 2015; Freydefont & Gendolla, 2012; Gendolla & Silvestrini, 2011; Lasauskaite Schüpbach et al., 2013; Silvestrini & Gendolla, 2011a). These cardiovascular responses during task performance relied on sympathetic nervous system impact and reflect effort (Obrist, 1981; Kelsey, 2012; Wright, 1996)—the mobilization of resources for action execution (Gendolla & Wright, 2009).

1.1. Implicit affect and effort

According to the IAPE model (Gendolla, 2012), affect primes—e.g., implicitly processed affective stimuli like facial expressions of emotions—can have effects on effort because they influence experienced task demand during performance. Individuals learn that accomplishing their tasks is easier in some affective states than in others. Thus, over time, ease and difficulty become features of their mental representations of affective states. Anger, in contrast to fear, is typically linked to high optimism and experiences of high coping potential (Lerner & Keltner, 2001). In the context of task performance, high coping potential diminishes the perception of task difficulty (see Wright, 1998; Wright et al., 2019), linking anger to the experience of *ease* (e.g., Gendolla & Silvestrini, 2011). By contrast, coping potential is typically low for fear (Lerner & Keltner, 2001), which is consequently linked to the experience of *difficulty*. Similarly, sad and happy moods influence experienced demand and effort (see Gendolla & Brinkmann, 2005; Richter et al., 2016, for recent review). Thus, people should learn over time that performing tasks is subjectively more demanding in a sad mood than in a happy mood. That way, *ease* should become a feature of their mental

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representation of happiness, while *difficulty* should turn into a feature of people's mental representation of sadness.

Based on the semantic priming principle (see Förster & Liberman, 2007; Neely, 1977), implicitly processed affect primes should render the performance ease and difficulty concepts accessible (e.g., Lasauskaite et al., 2017) and thereby influence experienced task demand and consequently effort. This is because resource mobilization is based on the principle of resource conservation (Gibson, 1900), which states that organisms avoid doing more than is necessary for attaining their goals. Therefore, effort increases with experienced task demand as long as success is possible and the necessary effort is justified (Brehm & Self, 1989). As a result, the IAPE model predicts higher effort for implicitly processed sadness or fear primes (information of difficulty, higher task demand) compared to implicitly processed happiness or anger primes (information of ease, lower task demand). The predictions of the IAPE model have found ample empirical support (see Gendolla et al., 2012, 2019; Richter et al., 2016; Silvestrini & Gendolla, 2019, for recent reviews).

In addition to the evidence for affect primes' influence on effort-related cardiovascular response, research on the IAPE model recently identified boundary conditions for this effect. Accordingly, affect primes only influence sympathetically mediated responses in the cardiovascular system if individuals are not aware of being primed (Framorando & Gendolla, 2018a, 2018b, 2019a; Lasauskaite Schüpbach et al., 2014), if the primes are processed in an achievement task context (Framorando & Gendolla, 2019b), and if the primes do not appear too frequently (Silvestrini & Gendolla, 2011a). This research demonstrates the importance of identifying and understanding boundary conditions and moderators of affect primes' effects on behavior and related physiological responses. Importantly, there is reason to believe that the way people engage in a task—by deliberation and personal choice vs. external assignment—might be another boundary condition for incidental implicit affective influences on effort. The present experiment tested this idea.

1.2. Action shielding by choice

Research on volition—the execution, maintenance, and protection of goal-directed action (Kuhl, 1986)—suggests that intention formation activates a set of cognitive processes that facilitate goal pursuit (Gollwitzer, 1990, 2012; Heckhausen & Gollwitzer, 1987). After committing to a goal or action, individuals enter into a mindset that facilitates goal striving 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 empirically demonstrated for potential goal conflicts, where goal commitment protects against the mental activation of alternative goals (Shah et al., 2002). Moreover, grounded in an action shielding model (Gendolla et al., 2021), a recent line of research tested whether the shielding effect would also apply to incidental affective influences on action execution. This research found that individuals who could personally choose between different tasks or task aspects were shielded against happy vs. sad background music effects on cardiovascular responses during task performance. By contrast, persons to whom the tasks or their characteristics were externally assigned—which is the default procedure in psychological experiments—did show music-induced affective influences on effort intensity, reflected by sympathetically mediated cardiovascular responses (Falk et al., 2022a, 2022b; Gendolla et al., 2021).

The logic behind this action shielding effect is that the personal choice of tasks or task characteristics immunizes against incidental affective influences on action execution. This reasoning is grounded in the psychology of volition: Intention formation has been associated with increased commitment (Bouzidi et al., 2022; Heckhausen & Gollwitzer, 1987; Nenkov & Gollwitzer, 2012; Ryan & Deci, 2006), a heightened task focus (Kuhl, 1986), and an implemental mindset that facilitates the processing of information needed for task completion (Gollwitzer, 1990, 2012). The present research tested whether the action shielding effect also applies to the influence of implicitly processed affect primes. That is, we tested whether briefly flashed and backward masked pictures of emotional faces, which were supposed to be sufficient for the implicit activation of participants' mental representations of emotional states, elicit effort-related responses in the cardiovascular system that have been identified in the research on the IAPE model (Gendolla, 2012, 2015). Importantly, participants who could ostensibly personally choose their task were expected to be shielded against this implicit affect prime effect.

1.3. Effort and cardiovascular response

According to Wright's (1996) integration of motivational intensity theory (Brehm & Self, 1989) with the active coping approach (Obrist, 1981), effort is reflected by beta-adrenergic sympathetic nervous system impact on the heart. Given that the sympathetic nervous system is responsible for activation and the cardiovascular system is the body's main resource transport system, this perfectly fits the operationalization of the effort construct, defined as resource mobilization for action execution (Gendolla & Wright, 2009). Beta-adrenergic sympathetic activity primarily influences cardiac contractile force, as reflected 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 with increasing beta-adrenergic impact and is highly sensitive to manipulations of task demand (e.g., Richter et al., 2008), incentives (e.g., Richter & Gendolla, 2009), and combinations of both (e.g., Silvestrini & Gendolla, 2011b).

Some studies have also used systolic blood pressure (SBP) to measure effort because cardiac contractility also affects cardiac output (the volume of blood pumped by the ventricles per minute) (see Gendolla et al., 2012; Richter et al., 2016; Wright & Kirby, 2001, for reviews). However, SBP is also influenced by peripheral vascular resistance, which is not systematically affected by beta-adrenergic activity (Levick, 2003). Other studies (e.g., Elliott, 1969) monitored effort with heart rate (HR). But HR is also influenced by the parasympathetic nervous system. Therefore, changes in PEP during task performance are the most sensitive and reliable index of effort among these indicators (Kelsey, 2012; Richter et al., 2008; Wright, 1996). Nevertheless, PEP should always be measured along with blood pressure and HR to monitor possible effects of preload (ventricular filling) or afterload (arterial pressure) on PEP (Sherwood, 1990).

1.4. The present experiment

We tested the moderating effect of task choice on implicit affect's influence on effort-related cardiovascular response, especially PEP, during a cognitive task of moderate difficulty. Half of the participants were ostensibly allowed to choose between two tasks (attention vs. memory), while the other half were assigned to a task selected by a yoked participant in the choice condition. In fact, all participants completed the same letter counting task that comprised both attention and memory aspects. Task trials started with the presentation of a briefly flashed and masked picture of a facial expression. Fear expressions were presented to half of the participants, and angry expressions to the other half.

Based on the IAPE model (Gendolla, 2012), we expected the fear primes to lead to stronger sympathetically mediated cardiovascular reactivity (reflecting effort intensity) than the anger primes in the moderately difficult task when the task was externally assigned, as previously demonstrated (e.g., Chatelain & Gendolla, 2015; Freydefont et al., 2012; Gendolla & Silvestrini, 2011). This is because fear primes should activate the *difficulty* concept and thus lead to experiencing higher task demand and exerting more effort than anger primes (activation of the *ease* concept and lower experienced task demand and effort). In contrast, participants should be shielded against the implicit affective influence on effort when they ostensibly could personally choose the task. According to the principles of motivational intensity theory (Brehm & Self, 1989; Wright, 1996), sympathetically mediated cardiovascular reactivity should therefore be low in general in the chosen task condition, because a moderately difficult task only necessitates moderate effort without the influence of the affect primes, even though personal choice increases commitment and thus the magnitude of *justified* effort (e.g., Bouzidi et al., 2022). Altogether, this results in the prediction of a 3:1 pattern with stronger cardiovascular reactivity (especially PEP) in the Assigned Task/Fear Primes condition than in the other three conditions.

2. Method

2.1. Design overview

All procedures and measures were approved by the local Ethics Committee, and participants were randomly assigned to one of the four experiment conditions in a 2 (Choice: chosen task vs. assigned task) × 2 (Primes: fear vs. anger) between-persons design.

2.2. Participants

Previous experiments on affect priming and task choice found significant effects of medium size on effort-related cardiovascular response 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 at least 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. According to a sensitivity analysis with G*power (Faul et al., 2007), this 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.

Participants were recruited through flyers distributed inside the university buildings and postings on the university's online job portal. Inclusion criteria were the following: Fluency in the French language, being in generally good health (no chronic illness, pacemaker, or use of antidepressants), and being at least 18 years old. Psychology students were not allowed to participate. To control for caffeine effects on the cardiovascular system (see Grant et al., 2018), participants were instructed not to consume any caffeine on the testing day. Additionally, participants were instructed not to consume heavy meals 2 h prior to testing to prevent digestion effects on the cardiovascular system. In total, we recruited 126 healthy students from different faculties. Participants received CHF 10 Swiss Francs (about 10.5 USD) for their participation.

2.3. Instrumentation and apparatus

2.3.1. Measures of cardiovascular activity

We used a Cardioscreen 1000 system (Medis, Ilmenau, Germany) to measure PEP and HR based on ECG and ICG signals. Four pairs of electrodes (Ag/AgCl; Medis, Ilmenau, Germany) were placed 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 1000 Hz), and analyzed offline (50 Hz low-pass filter) with BlueBox 2. V1.22 software (Richter, 2010). The first derivative of the change in thoracic impedance was calculated, and the resulting dZ/dt signal was averaged in 1-min intervals. The location of the B point was estimated on the basis of the RZ interval of valid cardiac 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 R onset in the ECG signal and the B point in the ICG signal (Berntson et al., 2004). HR was determined based on the ECG inter-beat intervals assessed with the Cardioscreen system.

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

2.3.2. Measures of affective state

Participants' affective state was assessed with two items related to fear (frightened, anxious) and two items related to anger (angry, irritated) on 7-point scales (1 – *not at all*, 7 – *very much*). Fear and anger scores were calculated for the pre- and post-task ratings by summing the respectively fear and anger items.

2.3.3. Cognitive task

The task required detecting and memorizing letters from different presented series of letters. This ensured that the task required both attention and memory. Participants were presented with 36 different series of 7 letters, each consisting of both consonants and vowels (e.g., "OIUTFHV"; "LNMEPRM") and were asked to report the letters that appeared twice in a series after the task; in total, there were 19 letters appearing twice in a series (5 × B; 4 × D; 3 × F; 2 × S; 3 × V; 2 × M). As depicted in Fig. 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 as backward mask (133 ms). After each backward mask, another fixation cross appeared (750 ms), followed by the series of 7 letters (4000 ms). The intertrial interval randomly varied between 2000 ms and 4000 ms.

2.3.4. Affect primes

We administered averaged, grayscale, low frequency, frontal perspective face pictures showing neutral (MNES, FNES), fear (MAFS, FAFS), and anger (MANS, FANS) expressions (50 % male, 50 % female) from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998) as affect primes. Half of the participants were presented with fear expressions, while the other half were presented with anger expressions. To avoid prime habituation effects (Silvestrini & Gendolla, 2011a), the affect primes were presented in only 1/3 of the trials; neutral faces were presented in the other trials. To ensure regular display of the affect primes, the affect prime presentation was randomized in a way that 2 emotional expressions were displayed during 6 trials.

2.4. Procedure

The experiment was approved by the local ethics committee. All participants voluntarily participated in the study and had the option to withdraw at any point during the experiment. Before starting the experimental procedure, participants were required to read and sign an informed consent form. This form provided an explanation of the basic experimental procedure (but not of the hypotheses) and requested participants' consent for their anonymized data to be analyzed and made available for scientific purpose. To avoid experimenter demand effects (e.g., Gilder & Heerey, 2018), the experimenter was recruited and unaware of both the hypotheses and the experimental conditions. To prevent biased behavior, the real purpose of the experiment was not communicated. Participants were seated in a comfortable chair and were fitted with the physiological sensors. Next, the experimenter started the computer program with the experimental protocol (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 then rated a neutral affect filler item ("do you feel balanced?"), before rating their affective state prior to being exposed to the affect primes. To avoid suspicion, these affect measures were introduced as default assessments since participants entered the laboratory in different states. Next, participants watched a hedonically

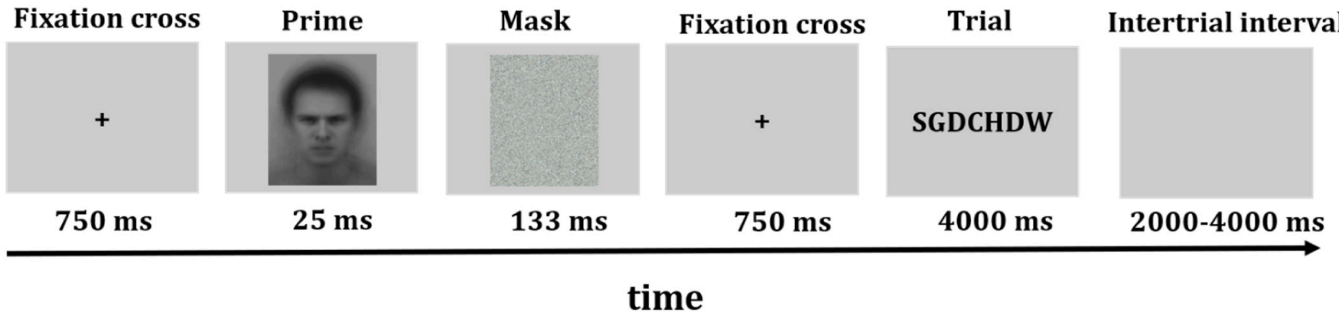

Fig. 1. Example of an experimental task trial. *Note.* In the example, the letter sequence "SGDCHDW" is displayed. Participants should memorize the letter "D" because it appears twice in the sequence.

neutral documentary about Norway (8 min) to establish cardiovascular baseline measures.

Next, participants entered the choice manipulation phase. In fact, all participants later worked on the same task, which comprised both attention and memory components. However, half of the participants were given the opportunity to choose whether they preferred working on an attention task or a memory task (Chosen Task condition). To give these participants a reason for their choice and to ensure some relevance of it, they 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 presented stimuli"); Attention task ("in an attention task, you must pay attention to the presented stimuli"). Then participants in the Chosen Task condition were asked to deliberate for 1 min: "Would you like to work on a memory task or an attention task?". After 1 min, participants were asked to choose the type of task they wanted to work on by pressing “1” for the memory task or “3” for the attention task. To ensure their commitment, participants were asked to confirm their decision. If they pressed “1” for "Yes", the procedure continued. If they pressed “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 instructions in line with their yoked participant in the Chosen Task condition. If the preceding participant in the Chosen Task condition had selected the memory task, the next participant in the Assigned Task condition read "Current research results show a positive effect on task performance when the cognitive task is a memory task." Correspondingly, when the yoked participant had chosen the attention task, the participant read "Current research results show a positive effect on task performance when the cognitive task is an attention task." That is, both the chosen and assigned tasks ostensibly had a positive effect on task performance. To keep the conditions further as parallel as possible, participants in the Assigned Task condition had a 1 min break before starting to work on the task.

All participants received identical task instructions, but with different headings—"Memory Task" or “Attention Task”, respectively. Then, participants all worked on the same cognitive task. Fig. 1 depicts the structure of a task trial.

After the task, all participants were asked to write down the letters that had appeared twice in a series. The exact order was not important. Before the main task, all participants had performed 10 practice trials to familiarize themselves with the task. The correct number of letters appearing twice in the training trial series was displayed at the end of the practice, so that participants could check the correctness of the letters they had detected and memorized.

After writing down the critical letters of the main task, participants rated the difficulty of the task on a continuous scale ("To what extent did you find the task difficult?") ranging from 1 (*not at all*) to 7 (*very difficult*). Next, participants rated the same 4 affect items as those presented at the beginning of the procedure. We had decided to omit a choice manipulation check in this experiment. We have used the same task choice manipulation before, and a manipulation check (“To what extent could you decide on the characteristics of the task?”) revealed a highly significant and strong effect on participants’ feelings of having had control which type of task they would worked on (Falk et al., 2022a), meaning that our manipulations’ validity has been established (see Hauser et al., 2018). Therefore, we are confident that the choice manipulation was also effective in the present study. Moreover, a choice manipulation question could have alerted participants in the Assigned Task condition—they could have realized that other participants could choose, which might have influenced their behavior. We wanted to avoid this possibility.

Finally, participants answered additional questions about their native language, French language skills, health status, and eventual medication. The experiment ended with a funnel debriefing in which participants were asked to guess the purpose of the study and to describe a task trial. Participants who reported to have seen flickers were asked to describe it. Finally, participants were fully debriefed about the study’s purpose and the manipulations.

2.5. *Data analysis*

We had a priori decided to calculate baseline scores by averaging the cardiovascular values of the last 3 min of the habituation phase, because cardiovascular activity usually becomes stable toward the end of habituation.

To test our predictions about the moderating effect of task choice on implicit affect’s influence on cardiovascular response, we ran 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 & Rosnow, 1985; Wilkinson & The Task Force on Statistical Inference of APA, 1999). We had predicted a 3:1 effort pattern with stronger cardiovascular responses, especially PEP, in the Assigned Task/Fear Primes condition (contrast weight $+3$) compared to the other 3 conditions (Assigned Task/Anger Primes, Chosen Task/Fear Primes, Chosen Task/Anger Primes; contrast weights -1). Conventional 2×2 ANOVAs were performed for variables for which we had no specific predictions (response accuracy, self-reported anger, fear, and task difficulty).

Data and data coding are available on the server that archives open access data at the University of Geneva: https://doi.org/10.26037/yareta:yoyrq3wdingfxp42hgmr33mhpa. After conducting an initial analysis to verify the data quality and identify any outliers, we excluded a total of five participants from the study. Two participants were excluded due to ECG or ICG signal loss, one participant because of an extremely low PEP baseline value (outside the normal data range for individuals with healthy cardiac conditions; Hodges et al., 1972), one participant because of excessive PEP/SBP reactivity ($>$ 3 *SDs* than the grand and condition means), and one participant because of misunderstood task instructions. This resulted in a final sample of $N = 121$ (mean age 23 years; $N = 120$ for SBP and DBP).

3. Results

Table 1 presents demographic data (gender and age), which did not significantly differ across conditions according to Pearson's Chi-Squared tests ($ps > 0.896$).

3.1. Cardiovascular baselines

The last 3 measures showed high internal consistency (Cronbach's $\alpha s \geq 0.95$). Cell means and standard errors of the baseline scores appear in Table 2. Preliminary 2 (Choice) × 2 (Primes) ANOVAs of the cardiovascular baseline scores revealed no significant a priori differences between conditions ($ps > 0.083$).[1]

3.2. Cardiovascular reactivity

We created reactivity scores by subtracting participants' baseline values from their five 1 min values of cardiovascular activity during task performance. Preliminary 2 (Choice) × 2 (Primes) × 5 (Minute) repeated-measures ANOVAs revealed significant time effects on the PEP, SBP, and DBP responses, $Fs > 3.99$, $ps < 0.006$, $\eta^2 > .03$. Follow-up comparisons showed significantly stronger reactivity during the first minute of the task than during the following minutes, $Fs > 4.94$, $ps < 0.029$, $\eta^2 > .04$, suggesting a general early disengagement. Therefore, we focused our cardiovascular reactivity analysis on the first minute of the task, as we had done in previous research that found the same time effect (e.g., Framorando & Gendolla, 2018a). Preliminary ANCOVAs revealed no significant associations between the baseline and reactivity scores ($ps > 0.292$).

3.2.1. PEP reactivity

In support of our hypothesis, the theory-based a priori contrast for PEP reactivity ($N = 121$)—our main effort-related cardiac measure—was significant, $F(1, 117) = 5.16$, $p = 0.025$, $\eta^2 = .04$. As depicted in Fig. 2, the pattern of PEP reactivity emerged as predicted (note that decreases in PEP are reflecting increases in beta-adrenergic sympathetic impact). For interested readers, further comparisons of cell means can be found in the Online Supplemental material.

Table 1
Demographic data. Age is presented as cell means and standard errors (in parentheses), while gender is shown as the number and percentage (in parentheses) of men and women in each condition.

	Chosen task		Assigned task	
	Fear primes	Anger primes	Fear primes	Anger primes
Age (mean)	21.81 (0.56)	22.47 (0.50)	23.16(0.50)	22.97 (0.61)
Gender (M/W)	10(32.3 %)/ 21(67.7 %)	11(36.7 %)/ 19(63.3 %)	11(35.5 %)/ 20(64.5 %)	9(31.0 %)/20 (69.0 %)

Note: M = men; W = women.

Table 2
Cell means and standard errors (in parentheses) of cardiovascular baseline scores.

	Chosen task		Assigned task	
	Fear primes	Anger primes	Fear primes	Anger primes
PEP	96.54 (2.03)	96.89 (1.95)	102.25 (2.72)	98.83 (2.48)
SBP	105.20 (1.62)	103.71 (1.85)	106.77 (1.96)	105.05 (1.96)
DBP	60.65 (0.95)	59.29 (1.24)	62.47 (1.09)	61.42 (1.24)
HR	75.39 (2.08)	74.20 (1.59)	77.68 (1.75)	75.77 (2.31)

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). $N = 121$ for PEP and HR, $N = 120$ for SBP and DBP.

3.2.2. SBP, DBP, and HR reactivity

Cell means and standard errors appear in Table 3. The 3:1 a priori contrasts for responses of SBP, $F(1, 116) = 1.16$, $p = 0.283$, $\eta^2 < .01$, DBP, $F(1, 116) = 0.21$, $p = 0.650$, $\eta^2 < .01$, and HR, $F(1, 117) = 1.07$, $p = 0.304$, $\eta^2 < .01$, were not significant, although the SBP and HR responses corresponded to the predicted reactivity pattern.

3.2.3. CO and TPR reactivity

For researchers interested in more details about hemodynamic responses that were unrelated to our hypotheses, results for cardiac output and total peripheral resistance are accessible in the Supplementary Online material. However, analyzes of these indices did not reveal any significant effects ($ps \geq 0.213$).

3.3. Task performance

Task performance was calculated using the total number of letters to be recalled (19) minus the number of errors. The number of errors was calculated as the difference between the number of target letters and the correct letters. For example: If the participant indicated the number of target letters as 1 or 5 when the correct number of target letters was 3, we counted such responses as 2 errors. On average, participants correctly reported 69.68 % ($SE = 1.63$) of the 19 letters that appeared twice in the letter series, suggesting that the task was moderately difficult. A 2 (Choice) × 2 (Primes) ANOVA ($N = 121$) revealed a significant Choice × Primes interaction effect, $F(1, 117) = 5.64$, $p = 0.019$, $\eta^2 = .05$; the main effects were non-significant ($ps > 0.373$). However, additional post-hoc Tukey tests revealed no significant cell differences (Chosen Task/Fear Primes: $M = 67.40$ %, $SE = 3.21$; Chosen Task/Anger Primes: $M = 74.74$ %, $SE = 2.78$; Assigned Task/Fear Primes: $M = 72.16$ %, $SE = 2.89$; Assigned Task/Anger Primes: $M = 64.25$ %, $SE = 3.90$) ($ps > 0.099$).

3.4. Verbal measures

3.4.1. Experienced affect

We created fear and anger sum scores for the pre-task ($rs \geq 0.64$, $ps < .001$) and post-task ($rs \geq 0.72$, $ps < 0.001$) affect measures. A 2 (Choice) × 2 (Primes) × 2 (Time) mixed-model ANOVA of the fear scores ($N = 115$ due to 6 missing values) revealed a significant Time main effect, $F(1, 111) = 16.49$, $p < 0.001$, $\eta^2 = 0.13$, reflecting higher fear scores before ($M = 6.02$, $SE = 0.32$) than after the task ($M = 4.98$, $SE = 0.28$). No other effect was significant ($ps \geq 0.098$). The mixed model ANOVA of the anger scores ($N = 117$ – 4 missing values) did not reveal any significant effects ($ps \geq 0.066$; grand $M = 3.29$, $SE = 0.17$).

Most relevant, ANCOVAs of PEP reactivity during the first minute of the task with the post-task affect ratings as covariates revealed no significant covariate effects ($ps > 0.302$) and the additional contrast of the PEP reactivity during the first minute of the task remained significant after controlling for rated fear or anger scores ($ps < 0.045$). This does not speak for the possibility that the affect primes triggered conscious feelings that in turn influenced the cardiac responses.

[1] The 3:1 contrast that tested our predictions about cardiovascular reactivity was not significant for any of the cardiovascular baseline values ($ps \geq 0.061$). For readers interested in gender differences, we also compared the cardiovascular baseline values of women and men. Including gender as an additional factor in the analyzes was not warranted because there were far more women than men. There were significant gender differences in the baselines of SBP, $t(118) = 7.24$, $p < .001$, $\eta^2 = 0.31$, and HR, $t(119) = 2.55$, $p = .012$, $\eta^2 = 0.05$. SBP values were higher for men ($M = 112.93$, $SD = 1.60$) compared to women ($M = 101.19$, $SD = 0.82$), while the HR values were higher for women ($M = 77.45$, $SD = 1.12$) than men ($M = 72.54$, $SD = 1.73$). The PEP and DBP baseline values did not significantly differ as a function of gender ($ps \geq 0.063$).

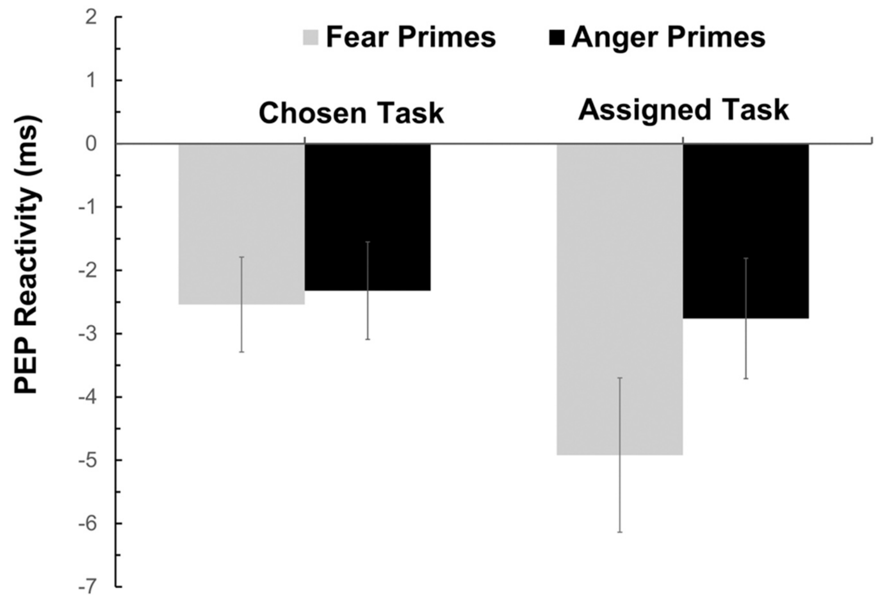

Fig. 2. Cell means and ± 1 standard errors of PEP reactivity (in ms) in the experimental conditions during the first minute of the task.

Table 3
Cell means and standard errors (in parentheses) of cardiovascular reactivity during the first minute of the task.

	Chosen task		Assigned task	
	Fear primes	Anger primes	Fear primes	Anger primes
SBP	4.51 (0.86)	4.49 (0.97)	5.94 (0.97)	5.24 (1.08)
DBP	3.39 (0.63)	3.31 (0.67)	3.75 (0.85)	3.37 (0.89)
HR	4.42 (1.17)	3.67 (0.77)	5.10 (1.06)	3.80 (1.01)

Note: SBP = Systolic Blood Pressure (in mmHg), DBP = diastolic blood pressure (in mmHg), HR = diastolic blood pressure (in beats/minute). $N = 120$ for SBP and DBP, $N = 121$ for HR.

3.4.2. *Task difficulty*

A 2 (Choice) × 2 (Primes) ANOVA of the task difficulty ratings ($N = 117$ due to 4 missing values; grand $M = 4.67$, $SE = 1.16$) revealed no significant effects ($ps \geq 0.450$). The grand mean suggests that the task was experienced as moderately difficult.

3.5. *Funnel debriefing*

No participant guessed the purpose of the present study. In the funnel debriefing, 6 participants (5 %) reported to have seen emotional faces, but only 1 participant could correctly report the type of emotional expression. This suggests that nearly all participants processed the affect primes implicitly, as intended. The number of participants who reported to have seen emotional faces in the Chosen Task and Assigned Task conditions were identical (3 participants in each condition, i.e. 2.5 %).

4. Discussion

The present experiment lends additional support to the action shielding model (Gendolla et al., 2021) and provides first evidence that personal task choice can immunize against implicit affective influences on effort assessed as sympathetically mediated cardiac response. This is an important extension of the already existing evidence for action-choice based shielding against more explicit affective influences, like pleasant and unpleasant music (Falk et al., 2002a, 2022b) or aversive noise (Falk et al., 2022c). Our study found that personal task choice can also shield action execution against implicit influences.

4.1. *Cardiovascular and performance effects*

Consistent with previous research on affect primes' effects on effort, participants in the present study's Assigned Task/Fear Primes condition showed stronger PEP responses than those in the Assigned Task/Anger Primes condition. This replicates previous findings for easy to moderately difficult tasks (e.g., Chatelain et al., 2016; Chatelain & Gendolla, 2015). Based on the IAPE model (Gendolla, 2012), this was expected for the present assigned task condition, because fear primes should activate the idea of performance difficulty, leading to increased experienced task demand and thus higher effort. Anger primes, on the contrary, should activate the idea of performance ease, leading to lower task demand and thus lower effort. Most importantly, the replicated effect of the anger and fear primes disappeared and led to weak PEP responses due to the moderate objective task difficulty when participants were induced to deliberate and subsequently personally choose their task. Based on our action shielding model (Gendolla et al., 2021), this was predicted because task choice is known to lead to increased commitment (Bouzidi et al., 2022; Heckhausen & Gollwitzer, 1987; Nenkov & Gollwitzer, 2012; Ryan & Deci, 2006), a strong action-oriented task-focus (Kuhl, 1986), and an implemental mindset (Gollwitzer, 1990). This should result in strong action shielding and consequently weak incidental influences on action execution. The present study provides first evidence that this shielding effect also applies to implicit affective influences on sympathetically mediated cardiac response reflecting effort.

At the physiological level, the a priori contrast modeled according to our effort-related predictions was significant for PEP reactivity, which was our main effort-related measure. The reactivity patterns of SBP, DBP, and HR were largely consistent with the expected effort pattern, but not significant. This is not surprising, as PEP is the most sensitive indicator of beta-adrenergic sympathetic impact on the heart and thus effort (Kelsey, 2012; Richter et al., 2008; Wright, 1996). Importantly, PEP reactivity was not accompanied by decreases in blood pressure or HR, making it implausible to attribute the PEP responses to cardiac preload or vascular afterload effects rather than beta-adrenergic sympathetic nervous system impact (see Sherwood et al., 1990).

The analysis of task performance revealed a significant Choice x Primes interaction effect on the percentage of correctly remembered letters. However, post-hoc cell comparisons revealed no significant differences. Descriptively, the performance pattern in the Assigned Task condition corresponded to that of our effort measure. Moreover, participants' response accuracy in the Chosen Task/Anger Primes condition tended to be higher than in the Assigned Task/Anger Primes condition. Although we did not formulate any predictions for performance effects and want to avoid speculation, this fits with previously reported beneficial effects of personal choice on performance (e.g., Legault & Inzlicht, 2013; Perlmutter, 1980). However, it is of note that performance and effort are different concepts and that the link between the two is more complex than simply linear. Moreover, performance could only be assessed for the entire task, while our effort effect occurred at the beginning of the task and cognitive performance depends on more than effort: Task ability, persistence, and the use of strategies are important additional factors to consider (Locke & Latham, 1990). The latter may especially apply to the task we have administered in which many different strategies could be used to perform well in memorizing the target letters. Nevertheless, overall task performance provided insight into the demand level of the administered task: The number of correctly recalled letters was moderate to high, indicating a moderate task difficulty. The same was suggested by participants' task difficulty ratings.

4.2. Effects on self-report measures

Regarding our self-report measures, participants' post-task difficulty ratings showed no significant effects. However, the IAPE model (Gendolla, 2012) is concerned with implicit effects on task demand *during* performance (which is what should influence PEP reactivity), rather than *after* performance. Nevertheless, some studies have also found affect prime effects on post-task difficulty ratings (e.g., Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011c). Assessing difficulty *during* the task is not possible without task interruptions which can easily bias participants' behavior or lead to disengagement. It is also possible that affect primes influence task demand on the implicit level without participants being aware of it (De Houwer et al., 2009). All this can explain why self-report did not show significant effects in our study, while the expected effort-related effects on PEP occurred as predicted—as in many other of our previous studies. To investigate the potential influence of affect primes on ease and difficulty concepts at the implicit level, future research could examine the use of implicit measures (e.g., Lasauskaite et al., 2017). However, we are confident that the present PEP responses during task performance reflect effort—defined as the mobilization of resources for action execution (Gendolla & Wright, 2009). Framorando and Gendolla (2019a) have compared the effect of affect primes on sympathetically mediated cardiovascular responses during performance of a task that called for effort with a non-achievement task context that did not call for effort. This study tested the possibility that affect primes may activate embodied representations of emotions (see Critchley et al., 2002; Lang et al., 1993) and therefore elicit cardiovascular responses. Framorando and Gendolla (2019a) found that sadness and happiness primes only had the expected effect on cardiovascular responses in an achievement context that called for effort, but not in a non-achievement context. This clearly supports our interpretation of PEP reactivity as reflecting effort—the mobilization of resources for action execution (Gendolla & Wright, 2009).

The administered affect primes had also no significant effects on our self-report measures of conscious affect, which is consistent with previous research examining implicit affective influences on effort (see Gendolla, 2012, 2015; Silvestrini & Gendolla, 2019, for reviews). Although zero effects do not permit firm conclusions, the lack of evidence for prime effects on consciously experienced affect fits with the IAPE model idea that affect primes do not require conscious affect to influence effort. Moreover, it is of note that the funnel debriefing revealed that only six of the 121 participants reported to have seen faces during the task, and that only one of them could indicate the presented emotional expressions. Accordingly, nearly all participants were unaware of what was primed, meaning that the present affective influences were as intended implicit, and that personal task choice could indeed shield against this implicit influence on action execution. This is an important new finding.

4.3. Theoretical implications

To date, research on goal and action shielding has mostly focused on conscious affect and other priming effects on behavior rather than on implicit affective influences. In our previous research, an action choice-based shielding effect has been observed for conflict priming (Bouzidi & Gendolla, 2023) and, most relevant, for explicit affective influences on effort (Falk et al., 2022a, 2022b; Gendolla et al., 2021). Importantly, the present study extends the shielding effect against explicit affective influences to the immunization against implicitly processed affect primes' impact, which can otherwise have clear effects on action execution in assigned cognitive tasks (see Gendolla, 2012, 2015). As in the previous research on the IAPE model, the implicit affective influence on effort-related cardiac response occurred only when participants worked on an externally assigned task. Most relevant, this replicated effect did disappear when participants could ostensibly choose their task.

In addition to providing first evidence that personal task choice can shield against implicit affective influences on effort-related cardiac response, the present study contributes to the understanding of implicit fear. Previous research on automatic resource mobilization has tested the effects of fear primes on effort (Chatelain & Gendolla, 2015, 2016; Chatelain et al., 2016), but not its boundary conditions. The latter was only investigated for anger, happiness, and sadness primes (Framorando & Gendolla, 2018a, 2018b, 2019a, 2019b; Lasauskaite Schüpbach et al., 2014).

Testing boundary conditions of implicit fear is particularly important because the visual processing of fearful faces can activate automatic neural processes that occur independently of conscious awareness (e.g., Anderson et al., 2013; Öhman & Mineka, 2001). According to Öhman and Mineka (2001), fear stimuli are processed by a specific encapsulated neural fear module (LeDoux, 1996, 2014) that, once activated, remains unaffected by other processes. Consequently, one could argue that the effects of fear primes on effort should be protected from other cognitive processes. However, our present findings argue against this idea because task choice eliminated the fear prime effect on cardiac PEP. This finding further sustains our idea that the present study's cardiovascular effects reflect effort rather than affective responses to visual emotional stimuli.

In a larger perspective, our present study does not only provide evidence that task choice moderates the effect of fear and anger primes on sympathetically mediated cardiac response in a mental concentration task, but also contributes to research on automaticity in general. Priming research has been criticized for replicability problems and mixed results (see Chivers, 2019). The present findings suggest that individuals' sense of control and autonomy is an important moderator to be considered in predicting priming effects on action. Therefore, the present study not only provides new insights into how and when primes influence effort in our experimental procedure, but also highlights new elements to consider for a better understanding of automaticity in general. It is well conceivable that feelings of personal control and autonomy that can be, among other conditions, induced by personal task choice are a boundary condition for priming effects. Further studying this possibility in future research could be important for understanding the conditions under which people's thoughts, feelings, and actions will be protected from priming effects. So far, keeping priming effects in check by volitional processes has only been studied in terms of making goals and plans that specify responses that are antagonistic to the primed response (if-then plans), and it was found that only if - then plans but not goals are an effective self-regulatory tool for shielding one's actions from disruptive concept- or goal-priming effects (Gollwitzer et al., 2011).

4.4. Implications for cardiovascular health

Strong cardiovascular reactivity is both a characteristic and a predictor of essential hypertension (e.g., Krantz & Manuck, 1984; Light et al., 1992)—that is, chronically elevated blood pressure above the population's norm. Hypertension is a main risk factor for the development of cardiovascular disease (World Health Organization, 2002). Studies have indicated that sympathetically mediated cardiovascular reactivity can predict both essential hypertension and cardiovascular disease in the long run (Light et al., 1992). Therefore, prolonged exposure to environmental factors that elevate sympathetically mediated cardiovascular responses may pose potential health risks. The roles of affective experiences (Gendolla & Richter, 2004) and self-relevant performance conditions (Gendolla et al., 2009) in this process have already been discussed. Implicit affect could be another factor to be considered, as research has shown how affect primes lead to strong cardiovascular responses (Gendolla, 2012, 2015).

Importantly, task choice has been identified as a potential mechanism to maintain moderate levels of cardiac response in moderately difficult challenges, which could be advantageous for long-term cardiovascular health. This is because it prevents environmental variables from causing a significant increase in cardiac response (Falk et al., 2022c). However, it is critical to recognize that (1) the present study represents only a snapshot and (2) effects were observed on PEP reactivity without significant effects on blood pressure. Thus, our findings do not yet indicate that exposure to implicitly processed affective stimuli represents a health risk. But future research should investigate the long-term effects of personal task choice and implicit affect on cardiac and vascular responses to better understand the role of these variables in the development of hypertension and cardiovascular disease.

4.5. Coda and outlook

The present experiment extends previous research on the action shielding effect (Gendolla et al., 2021) and contributes to research on the identification of moderators and boundary conditions of implicit processes in action execution. Importantly, our study found the first evidence that personal task choice can protect against implicit affective influences on sympathetically mediated cardiac response in a moderately difficulty cognitive task. It should be noted, however, that our findings are limited to the administered affective stimuli—fear and anger primes—and the moderately difficult cognitive task participants performed. A replication and extension of this study with other affect primes and task difficulty levels would be beneficial to confirm and extend our present new findings. Nevertheless, our present study provides a strong demonstration of the power of personal choice in action control: As predicted in our action-shielding model (Gendolla et al., 2021), personal task choice appears to create a state of mind that protects action execution even from implicit affective influences.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Guido H.E. Gendolla reports financial support was provided by Swiss National Science Foundation. Guido H.E. Gendolla reports a relationship with Swiss National Science Foundation that includes: funding grants. Guido H.E. Gendolla is Editorial Board member of Biological Psychology.

Data Availability

The data and data coding for the here reported studies are available on the open access data archiving server of the University of Geneva: https://doi.org/10.26037/yareta:yoyrq3wdingfxp42hgmr33mhpa.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.biopsycho.2023.108616.

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