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How to cite

FRAMORANDO, David et al. The power of personal control: Task choice attenuates the effect of implicit sadness on sympathetically mediated cardiac response. In: Psychophysiology, 2023, p. e14495. doi: 10.1111/psyp.14495

This publication URL: https://archive-ouverte.unige.ch/unige:174402
Publication DOI: 10.1111/psyp.14495

The Power of Personal Control: Task Choice Attenuates the Effect of Implicit Sadness on Sympathetically Mediated Cardiac Response

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Final accepted version of:

Framorando, D., Falk, J. R., Gollwitzer, P. M., Oettingen, G., & Gendolla, G. H. E. (2023). The power of personal control: Task choice attenuates the effect of implicit sadness on sympathetically mediated cardiac response. *Psychophysiology,* Article e14495. Advance online publication. https://doi.org/10.1111/psyp.14495

Author Note

This research was supported by a grant from the Swiss National Science Foundation (SNF 100014_185348) awarded to Guido H.E. Gendolla. We thank Giorgia Antonia Bergmann for her help as hired experimenter. The data and data coding for the here reported studies are available on Yareta—the open access data archiving server of the University of Geneva: https://doi.org/10.26037/yareta:vfnnulbacrcardbwluhunjmy4a

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Abstract

Implicitly processed pictures of facial expressions of emotions have been found to systematically influence sympathetically mediated cardiovascular reactivity during task performance. According to the Implicit-Affect-Primes-Effort model, this happens because different affect primes activate the concepts of performance ease vs. performance difficulty. Grounded in a recent action shielding model, our laboratory experiment (N = 129 university students) tested whether engaging in action by personal choice can immunize against those implicit affective influences on effort. Participants worked on an objectively difficult cognitive task, which was either externally assigned or ostensibly personally chosen. As predicted, participants in the assigned task condition showed weaker cardiac pre-ejection period reactivity during task performance, reflecting disengagement, when they were primed with sadness than when they were exposed to anger primes. Most relevant, this affect prime effect disappeared when participants could ostensibly choose their task themselves. These findings replicate previous research on implicit affect's impact on sympathetically mediated cardiac response and extend the literature on action shielding by personal choice effects to implicit affective influences on action execution.

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

Introduction

Several studies have found that affective stimuli that are implicitly processed during the performance of cognitive tasks systematically influence cardiovascular responses (see Gendolla et al., 2012, 2019; Richter et al., 2016; Silvestrini & Gendolla, 2019, for overviews). These physiological adjustments are the result of sympathetic nervous system impact on the cardiovascular system and have been considered to reflect changes in effort intensity (Obrist, 1981; Wright, 1996)—the mobilization of resources for action execution (Gendolla & Wright, 2009).

According to the Implicit-Affect-Primes-Effort (IAPE) model (Gendolla, 2012), affect primes take effect on effort and related physiological adjustments by influencing subjective task demand during performance. As individuals learn that accomplishing tasks is easier in certain emotional states than in others, ease and difficulty become features of these different affective states' mental representations: Happiness and anger become associated with ease, while sadness and fear become associated with difficulty. Based on the semantic priming principle (see Förster & Liberman, 2007; Neely, 1977), implicitly processing affect primes during a task should therefore render the concepts of ease or difficulty accessible, leading to lower or higher subjective task demand and corresponding effort. This is because resource mobilization is grounded in a resource conservation principle (Gibson, 1900), which states that organisms avoid doing more than necessary to achieve their goals. As a result, effort increases with experienced task demand as long as success is possible and the necessary effort is justified (Brehm & Self, 1989).

Accordingly, the IAPE model predicts for easy to moderately difficult tasks higher effort for priming sadness or fear (higher subjective task demand) compared to priming happiness or anger (lower subjective task demand) (e.g., Chatelain & Gendolla, 2015; Gendolla & Silvestrini, 2011). By contrast, when people work on objectively difficult tasks, the IAPE model predicts opposite prime effects: Here, happiness and anger primes should lead to higher effort than sadness or fear primes. This is because happiness and anger primes result in high but feasible subjective demand and thus high effort, while priming sadness or fear leads to the experience of excessive demand and thus low effort reflecting disengagement (e.g., Chatelain et al., 2016; Freydefont et al., 2012; Silvestrini & Gendolla, 2011b). However, the effort deficit of people who are primed with sadness or fear during a difficult task can be compensated by high reward that justifies the very high effort that appears to be necessary in this context (e.g., Chatelain et al., 2016; Freydefont & Gendolla, 2012).

To date, research in the context of the IAPE model has tested the effects of implicit affect primes on cardiovascular responses with assigned tasks in which participants could not choose the task or its characteristics. Importantly, recent research on action shielding provides reason that the way in which participants engage in a task—through personal choice vs. external assignment—may moderate the effects of implicit affective influence on effort.

Action Shielding by Choice

Theorizing on volition—the execution, maintenance, and protection of goal-directed actions (Kuhl, 1986)—suggests that the formation of intentions activates a set of cognitive processes that support goal attainment (Gollwitzer, 1990; Heckhausen & Gollwitzer, 1987). Once individuals have choosen a goal or action, they enter a mindset that supports goal attainment by heightened commitment to succeed on the task (Bouzidi et al., 2022) and a strong focus on the task, which results in action shielding that protects goal pursuit from interference by conflicting goals, temptations, or irrelevant information (see Gollwitzer, 1993). This shielding effect has been demonstrated in research on goal conflict, where active goals were protected from the mental activation of alternative goals (e.g., Shah et al., 2002). Importantly, recent research found that the shielding effect also applies to the impact of incidental affective influences on action execution.

Shielding Against Affective Influences

Grounded in the action shielding model (Gendolla et al., 2021) it was found that individuals who could personally choose the type of task or task aspects were protected against the effects of happy versus sad background music on sympathetically mediated cardiovascular responses during task performance. However, individuals to whom the task or its characteristics were externally assigned—which is the typical procedure in psychology experiments—did show music-induced affective influences on effort (Falk et al., 2022a, 2022b; Gendolla et al., 2021). The logic behind this action shielding effect is that choosing tasks or task characteristics oneself provides immunity against incidental affective influences on action execution. This reasoning is rooted in the above discussed psychology of volition. The formation of intentions has been linked to increased commitment (Bouzidi et al., 2022; Heckhausen & Gollwitzer, 1987; Nenkov & Gollwitzer, 2012; Ryan & Deci, 2006), heightened task focus (Kuhl, 1986), and an implemental mindset that facilitates the processing of information needed for task completion (Gollwitzer, 1990, 1993). Besides shielding against incidental affective influences, personal task choice also led to higher effort in difficult tasks (Falk et al., 2022a). This is because personal task choice increases the commitment to succeed (Nenkov & Gollwitzer, 2012), which justifies higher effort that is exerted if necessary (Bouzidi et al., 2022).

There is also first evidence for a shielding effect against implicit affective influences on effort (Framorando et al., 2023). However, the manipulation effects were limited to the beginning of the task. Participants worked on a moderately difficult task that was either personally chosen or externally assigned. Half of the participants were presented with fear primes, while the other half processed anger primes during task performance. When the task was externally assigned, the fear primes resulted in stronger sympathetically mediated cardiac responses than anger primes (Framorando et al., 2023)—a replicated effect (Chatelain & Gendolla, 2015). Most importantly, however, the effect of the affect primes disappeared when participants had personally chosen their task. A corresponding pattern of results was found for primed cognitive conflict, which is aversive, vs. non-conflict primes (Bouzidi & Gendolla, 2022).

Summing up, besides the manifold positive choice effects on motivation (see Patall, 2012, 2019; Patall et al., 2008, for reviews), choosing tasks or task aspects oneself shields against affective influences on action execution and justifies relatively high effort. In the present study, we tested whether this action shielding by choice effect also extends to immunizing against the effect of implicitly processed sadness primes on effort in a difficult cognitive task. In such conditions, personal task choice should lead to (1) high justified effort (i.e., high potential motivation), and (2) a shielding effect against implicit affective influences. According to the principles of motivational intensity theory (Brehm & Self, 1989), this should result in relatively high effort intensity that is due to the high task demand and justified by the choice-induced increased commitment.

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). This impact becomes evident in cardiac contractile force, 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). The shorter this time interval becomes during task performance, the more intense is the exerted effort (Kelsey, 2012).

Several studies have used systolic blood pressure (SBP) as a measure of effort since cardiac contractile force 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—and to a stronger degree diastolic blood pressure (DBP)—also depends on peripheral vascular resistance, which is not systematically affected by beta-adrenergic activity (Levick, 2003). Moreover, sympathetic impact on systolic and diastolic blood pressure can be masked or mirrored by parasympathetic activity changes in heart rate (HR), which has also been used to assess effort (e.g., Elliot, 1969; Eubanks et al., 2002), but depends besides sympathetic also on parasympathetic activation. Moreover, blood pressure responses can be masked by changes in preload (ventricular filling) or afterload (arterial pressure) (Bugge-Asperheim & Kiil, 1973), because those are influenced by stroke volume. Therefore, among these cardiovascular activity indices, changes in PEP during task performance are considered as the most sensitive and reliable indicator for testing effort-related predictions (Kelsey, 2012; Richter et al., 2008). Nevertheless, PEP should always be measured along with HR and diastolic blood pressure to respectively monitor possible preload or afterload effects on PEP. One should only attribute PEP responses to beta-adrenergic sympathetic impact if decreases in PEP are not accompanied by simultaneous decreases of HR or blood pressure (Sherwood et al., 1990).

The Present Experiment

We tested the moderating effect of task choice on implicit affect's influence on sympathetically mediated cardiovascular reactivity, especially PEP. We administered a highly challenging type of cognitive task that was previously utilized to test (1) the effects of task choice on explicit affective influence on effort (Falk et al., 2022a), and (2) the impact of task context on effort (Framorando & Gendolla, 2019a). As in previous studies (Falk et al., 2022a; Framorando et al., 2023; Gendolla et al., 2021), 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 later completed the same difficult letter counting task that comprised both attention and memory components. Task trials started with the presentation of a briefly flashed and masked picture of a facial expression. Half of the participants were presented with sad faces, while the other half were exposed to angry faces.[1]

Based on the IAPE model (Gendolla, 2012), we expected the sadness primes to lead to a weaker sympathetically mediated cardiovascular reactivity than anger primes when the difficult task was externally assigned (e.g., Freydefont et al., 2012). This is because sadness primes should lead to excessive subjective task demand during

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[1] We chose sadness vs. anger primes for the present study because they should affect subjective task demand in opposite directions (higher task demand for sadness primes; lower task demand for anger primes). The current study is part of a broader research program, and we leave it to future studies to examine task choice effects on the impact of fear vs. anger, fear vs. happiness, or sadness vs. happiness primes on cardiovascular responses during task performance. Administering fear vs. anger primes, fear vs. happiness primes, or sadness vs. happiness primes should yield results that are in line with those of the current study.

performance and thus disengagement, while anger primes should result in high but feasible task demand. Most relevant, based on the action shielding model (Gendolla et al., 2021), we expected this affect prime effect to disappear, reflecting immunization against the implicit affective influence on effort, when participants could ostensibly personally choose their task. There, task choice should lead to an increased commitment to succeed on the task (Nenkov & Gollwitzer, 2012). According to the principles of motivational intensity theory (Brehm & Self, 1989), this should justify the high effort that was necessary for performing well on the 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 predictions can be tested with a 3:1 contrast testing for weaker cardiovascular reactivity (especially PEP) in the Assigned Task/Sadness Prime condition than in the other three conditions.

Method

Participants and Design

Our recent studies that tested manipulations of task choice and affect priming had found significant effects of medium size on sympathetically mediated cardiovascular responses (e.g., Falk et al., 2022a, 2022b; Framorando & Gendolla, 2018a; Gendolla et al., 2021). Obtaining the same with 80% power for 1 *df* between persons contrast and ANOVA tests required N = 128 participants according to a G*Power analysis (Faul et al., 2007). To ensure this sample size after possible data loss due to technical problems or participant exclusion, we recruited 134 first year psychology students in exchange for partial course credit and randomly assigned them to the experimental conditions of a 2 (Choice: chosen task vs. assigned task) x 2 (Primes:

sadness vs. anger) between-persons design.

Two participants had to be excluded due to electrocardiogram (ECG) or impedance cardiogram (ICG) signal loss, one because of having a cardiac pacemaker, one due to misunderstood task instructions, and one because of extremely low response accuracy in the cognitive task (< 3 *SD*s than both the condition and grand *M*s). This resulted in a final sample of $N = 129$ (101 women, 28 men) with a mean age of 22 years (*SE* = 0.51; *Median* = 20; *Range* = 17-48).[2]

Affect Primes

We administered averaged, grayscale, low frequency, frontal perspective face pictures showing neutral (MNES, FNES), sadness (MSAS, FSAS), and anger (MANS, FANS)[3] expressions (50% male, 50% female) from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998) as affect primes.

Apparatus and Physiological Measures

We used a Cardioscreen 1000 system (Medis; Ilmenau, Germany) to measure PEP and HR based on ECG and ICG signals. We placed four pairs of single-use electrodes (Ag/AgCl; Medis; Ilmenau, Germany) 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). R-peaks were automatically identified using a threshold peak detection algorithm and visually

[2] The final sample consisted of 101 women and 28 men. The distributions of women and men were balanced across the conditions: Chosen Task/Sadness Primes (25 women, 8 men), Chosen Task/Anger Primes (25 women, 8 men), Assigned Task/Sadness Primes (27 women, 5 men), and Assigned Task/Anger Primes (24 women, 7 men) and did not differ between the four conditions according to a chi-square test ($p = .811$).

[3] M = Male, F = Female, SA = Sadness, AN = Anger, S = Straight View. Example: MNES = Male Neutral Straight View.

confirmed, allowing to determine HR. The first derivative of the change in thoracic impedance was calculated, and the resulting dZ/dt signal was averaged over 1-min periods, based on the detected R-peaks. The location of the B point was estimated based on the RZ interval of valid cardiac cycles (Lozano et al, 2007). The identified B point locations were then visually inspected and manually corrected if necessary, following the recommendations of Sherwood et al. (1990). This latter step was made on the raw data level by one of the authors, who was unaware of the experimental condition of the participants and the condition *M*s during this process. 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 DBP were measured oscillometrically in 1-minute intervals with a Dinamap ProCare monitor (GE Healthcare, Milwaukee, WI). The blood pressure cuff, which inflated automatically in 1-min intervals, 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

All procedures and measures were approved by the local Ethics Committee. To avoid experimenter effects (e.g., Gilder & Heerey, 2018), the experimenter was recruited and unaware of both the hypotheses and the experimental conditions. When subscribing to the experiment, participants were asked not to consume caffeinated beverages (e.g., tea, coffee, or cola) and not to exercise for at least 2 hours before the experiment. Upon arrival, they were welcomed, seated in a comfortable chair in front of a computer, and provided written informed consent. Before starting the experiment, participants were equipped with the physiological sensors. Then, 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.

The protocol started with biographical questions (age, gender)[4] and the rating of a neutral affect filler item ("do you feel balanced") before participants rated their baseline affective state prior to the exposure to the affect primes (2 sadness items: sad, down; 2 anger items: angry, irritated) on 7-point scales (1 - *not at all*, 7 - *very much*). To prevent suspicion, these affect ratings were introduced as standard measures to account for potentially different feeling states of participants entering the laboratory. Next, participants watched a hedonically neutral documentary video about Norway (8 min) to establish cardiovascular baseline measures. Participants were instructed to be passive and to relax. After the baseline period, participants entered the choice manipulation phase.

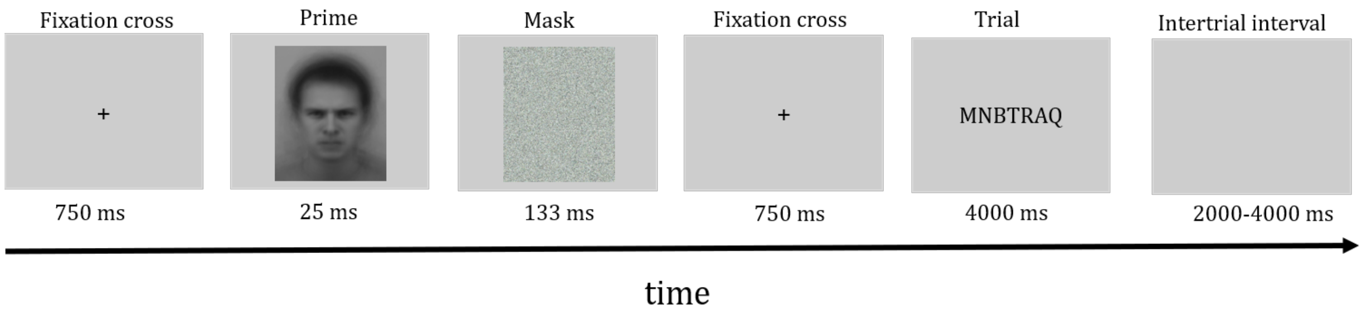
It is of note that all participants later worked on the same task, which comprised both attention and memory components. However, half of the participants were ostensibly given the opportunity to personally choose between two tasks: An attention or a memory task (Chosen Task condition). To give these 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." On the next screen, the two types of tasks were described: Memory task ("in a memory task, you must remember the presented stimuli"); Attention task ("in an attention task, you must

[4] Besides "female" and "male", participants were given a third option labeled "other" to indicate non-binary gender identification. No participant selected this option.

pay attention to the presented stimuli"). Then participants in the Chosen Task condition were asked to deliberate for 1 minute: "Would you like to work on a memory task or an attention task?". At the end of the 1 minute, 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 worked with the same type of task chosen by their yoked participant in the Chosen Task condition. If she or he had chosen the memory task, the participant 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. Instead of the 1 minute of deliberation, participants in the Assigned Task condition had a 1-minute break before starting to work on the task. That way we wanted to establish the highest possible correspondences between the Chosen and Assigned Task conditions, except for the ostensible opportunity to choose.

The following task instructions were identical for all participants except for the headings—"Memory Task” or “Attention Task”, respectively—depending on the Chosen Task condition participants’ choice. The task required detecting and memorizing target letters in presented series of letters. This ensured that the task had both continued attention and memorizing components. Participants were presented with 36 different series of 7 letters, consisting of only consonants (e.g., “MLPSKJH”) or consonants and a vowel (e.g., “GHJKEPM”). Participants were asked to count the numbers of appearing vowels (A, E, I, O, U) and to write them down at the end of the task. In total, there were 25 vowels appearing in the series (3 × A; 8 × E; 5 × I; 5 × O; 4 × U). To ensure that task difficulty was high, participants were asked to attain a high success criterion: They were asked to report at least 23 correct vowels out of the 25 presented during the task to succeed on the task. According to pretests and previous studies (e.g., Falk et al., 2022a; Framorando et al., 2019a), this task should be experienced as difficult.

Figure 1. Example of an experimental trial.



Note. In the example, the letter series "MNBTRAQ" is displayed. Participants should memorize the letter "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 as backward mask (133 ms).[5] Half of the participants were presented with sadness 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, while neutral faces appeared in the other trials. The affect prime presentation was randomized in a way that 2 emotional expressions were displayed during 6 trials,

[5] To stay consistent with previous studies on affect priming and effort (e.g., Framorando & Gendolla, 2018a, 2018b, 2019a, 2019b, 2023), primes were presented for 25 ms.

ensuring regular display of the affect primes. After each backward mask, another fixation cross appeared (750ms), followed by a series of 7 letters (4000 ms). The intertrial interval randomly varied between 2000 ms and 4000 ms.

After the task, all participants were asked to write down the correct number of vowels that had been presented in the letter series. Before the main task, all participants had performed 8 practice trials to familiarize themselves with the task. In the practice trials, only neutral facial expressions were used as primes (presented for 25 ms). Thereafter, participants were presented with the correct number of vowels that had occurred during the practice trials so that they could check the accuracy of the number of vowels they had counted.

Next, 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*) and rated the same 4 affect items as those presented at the beginning of the procedure.[6] Finally, they answered additional questions about their native language, French language skills, cardiovascular 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 them.

Results

[6] 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' perceptions of having control over the type of task they would work on (Falk et al., 2022a). Therefore, we are confident that the choice manipulation was also effective in the present study. Moreover, a choice manipulation question could have made the participants in the Assigned Task condition aware that others had the ability to choose, potentially influencing their behavior. We wanted to prevent this possibility.

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:vfnnulbacrcardbwluhunjmy4a. We tested our hypothesis about the moderating effect of task choice on implicit affect's influence on sympathetically mediated cardiovascular reactivity with an *a priori* contrast analysis—the most powerful and consequently the most appropriate statistical tool for testing predicted patterns of means (Rosenthal & Rosnow, 1985; Wilkinson & The Task Force on Statistical Inference of APA, 1999). As outlined above, our predicted effort pattern can be tested with a 3:1 a *priori contrast* reflecting weaker cardiovascular responses, especially PEP, in the Assigned Task/Sadness Primes condition (contrast weight +3) and stronger reactivity in the other 3 conditions (Assigned Task/Anger Primes, Chosen Task/Anger Primes, Chosen Task/Sadness Primes; contrast weights -1 each). Conventional 2 x 2 ANOVAs were performed for variables for which we had no specific predictions.

Cardiovascular Baselines

As in previous studies (e.g., Bouzidi & Gendolla, 2022; Falk et al., 2022a, 2022b; Framorando et al., 2023; Gendolla et al., 2021), we had *a priori* decided to calculate participants' cardiovascular baseline values by averaging the measures taken during the last 3 minutes of the habituation phase. We did so because cardiovascular activity typically becomes stable toward the end of habituation periods. These scores showed high internal consistency ($\omega s \geq .96$). Preliminary 2 (Choice) x 2 (Primes) between persons ANOVAs of the baseline scores found no significant *a priori* differences between the conditions (*ps* > .288).[7]

Table 1 Cell means and standard errors (in parentheses) of cardiovascular baseline scores.				
	Chosen Task		Assigned Task	
	Sadness Primes	Anger Primes	Sadness Primes	Anger Primes
PEP	99.35 (1.82)	101.47 (1.60)	100.20 (2.07)	100.67 (2.17)
SBP	105.37 (1.74)	105.05 (1.80)	104.17 (1.63)	105.81 (2.14)
DBP	61.61 (1.09)	61.23 (1.16)	62.41 (1.05)	61.40 (1.05)
HR	79.30 (2.08)	78.32 (2.06)	77.42 (1.86)	80.88 (2.30)

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* = 129 for PEP and SBP, *N* = 127 for DBP, and *N* = 128 for HR.

Cardiovascular Reactivity

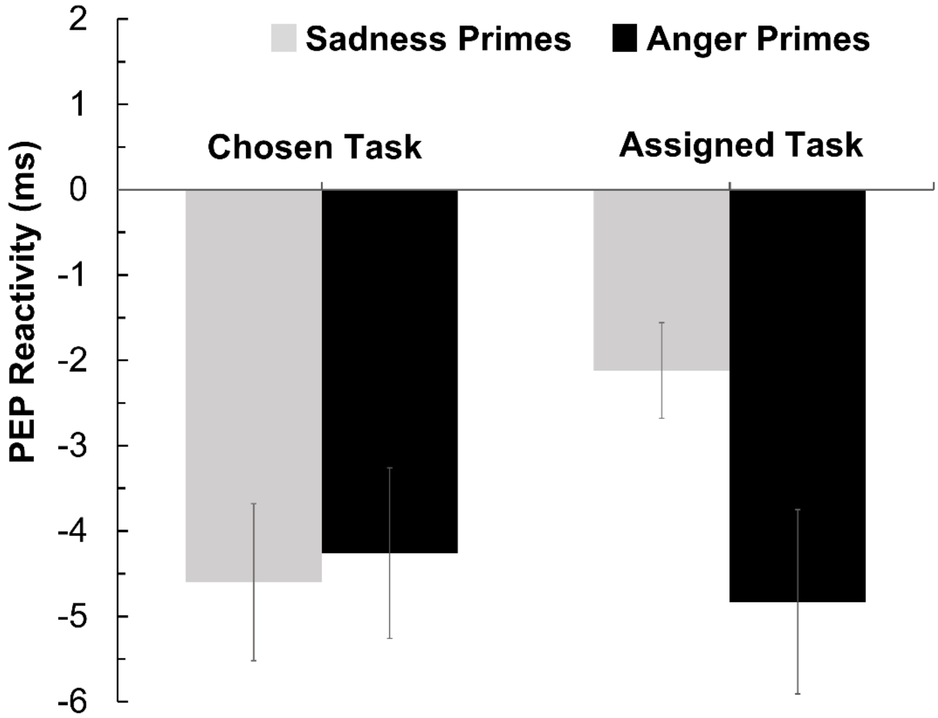
We created cardiovascular reactivity scores by subtracting participants' baseline scores from the averaged values of the five 1-min values of PEP, HR, SBP, and DBP that were assessed during task performance. These values showed high internal consistency (ωs ≥ .97). One participant was excluded from the HR reactivity and two from the DBP reactivity analyses because of excessive responding (> 3 *SD*s than the condition *M* of HR and DBP, respectively). Preliminary 2 (Choice) x 2 (Primes) analyses of covariance (ANCOVAs) of the averaged cardiovascular reactivity scores with the respective

[7] The 3:1 contrast that tested our predictions about cardiovascular reactivity was not significant for any of the cardiovascular baseline values (*ps* ≥ .387). 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 analyses was not warranted because there were far more women than men. There were significant gender differences in the baselines of SBP, $t(127) = 6.49$, $p < .001$, $\eta^2 = .25$, and DBP, $t(125) = 2.89$, $p = .004$, $\eta^2 = .06$. SBP and DBP values were higher for men (*M* = 114.82, *SE* = 1.92 vs. *M* = 102.40, *SE* = 0.86) than for women (*M* = 64.66, *SD* = 1.14 vs. *M* = 60.88, *SD* = 0.58), which is typical. The PEP and HR baseline values did not significantly differ as a function of gender (*ps* ≥ .219).

baseline scores as covariate found no significant associations between baseline and reactivity scores for any cardiovascular index (*ps* ≥ .206).

PEP reactivity. In support of our hypothesis, the theory-based *a priori* contrast for PEP reactivity—our main measure of sympathetically mediated cardiovascular reactivity—was significant, $F(1, 95.48) = 9.15$, $p = .003$, $\eta^2 = .09$.[8] As depicted in Figure 2, the pattern of PEP reactivity emerged as predicted—note that decreases in PEP are reflecting increases in beta-adrenergic sympathetic impact.

Figure 2. Cell means and ±1 standard errors of PEP reactivity (in ms) in the experimental conditions.



Additional follow-up cell contrasts found that the PEP reactivity in the Assigned Task/Sadness Primes condition ($M = -2.12$, $SE = 0.56$) was as expected significantly weaker than in the Assigned Task/Anger-Prime Condition, $t(45.23) = 2.23$, $p = .015$, η^2

[8] According to a Levene's test, the variances significantly differed between the conditions ($p = .038$). Therefore, we tested our a priori contrast with degrees of freedom and a *p*-value adjusted for unequal variances.

= .10, (M = -4.83, SE = 1.08), the Chosen Task/Sadness-Prime Condition, $t(52.45) = 2.28$, $p = .014$, $\eta^2 = .09$, (M = -4.60, SE = 0.93), and the Chosen Task/Anger-Prime Condition, $t(50.40) = 1.87$, $p = .034$, $\eta^2 = .07$, (M = -4.26, SE = 0.99).[9] Moreover, the other three conditions did not significantly differ from one-another, $ts > 1.22$, $ps > .225$, $\eta^2 < .03$. This confirms our predictions.

SBP, DBP, and HR reactivity. Cell means and standard errors appear in Table 2. The 3:1 *a priori* contrasts for SBP, DBP, and HR reactivity were not significant, $ts > 1.39$, $ps > .166$, $\eta^2 < .02$, although the SBP and HR responses largely corresponded to the expected effort pattern.[10]

Table 2
Cell means and standard errors (in parentheses) of cardiovascular reactivity during the first minute of the task.

	Chosen Task		Assigned Task	
	Sadness Primes	Anger Primes	Sadness Primes	Anger Primes
SBP	6.43 (0.85)	5.65 (0.83)	5.20 (0.77)	6.65 (0.89)
DBP	3.06 (0.62)	2.76 (0.52)	4.18 (0.65)	4.44 (0.60)
HR	6.05 (1.02)	4.85 (1.15)	4.44 (0.60)	6.16 (1.26)

Note: SBP = systolic blood pressure (in mmHg), DBP = diastolic blood pressure (in mmHg), HR=heart rate (in beats/minute). N = 129 for SBP, N = 127 for DBP, and N = 128 for HR.

Task Performance

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

[10] The Levene test revealed that the variance significantly differed between the conditions for HR reactivity (p = .015). The Levene test was not significant for SBP and DBP reactivity (ps > .397). Thus, we report the contrast p-value and degrees of freedom for HR reactivity that were adjusted for unequal variances.

Participants' performance was calculated based on the total number of vowels to be recalled and noted (25) minus the number of errors.[11] On average, participants correctly reported 87.66% (*SE* = 0.81) of the 25 vowels. A 2 (Choice) x 2 (Primes) ANOVA revealed no significant main effects, *Fs*(1, 125) > 0.58, *ps* > .444, $\eta^2 \leq .01$, but a marginally significant Choice x Primes interaction, *F*(1, 125) = 3.81, *p* = .053, $\eta^2 = .03$. However, additional *post-hoc* Tukey tests revealed no significant cell-mean differences (Chosen Task/Sadness Primes: *M* = 85.09%, *SE* = 1.62; Chosen Task/Anger Primes: *M* = 89.45%, *SE* = 1.43; Assigned Task/Sadness Primes: *M* = 89.00%, *SE* = 1.65; Assigned Task/Anger Primes: *M* = 87.10%, *SE* = 1.72), (*ps* > .208). Also the 3:1 *a priori* effort contrast was not significant, *F*(1, 125) = 0.96, *p* = .338, $\eta^2 < .01$.

Verbal Measures

Experienced affect. We created sadness and anger sum scores for the pre-task (*r*s ≥ .71, *p*s <. 001) and post-task (*r*s ≥ .63, *p*s < .001) affect measures. 2 (Choice) x 2 (Primes) x 2 (Time) mixed-model ANOVAs of the sadness and anger scores did not reveal any significant effects, *Fs* > 3.13, *ps* > .079, $\eta^2 \leq .03$.[12] Accordingly, there was no evidence that the affect priming procedure had induced conscious feelings.

We also ran additional ANCOVAs of PEP reactivity with the post-task affect ratings as covariates, which revealed significant associations between the reactivity scores of PEP and both the sadness, *F*(1, 124) = 6.05, *p* = .015, $\eta^2 = .05$, and anger scores, *F*(1, 124) = 4.78, *p* = .031, $\eta^2 = .03$. However, the contrasts of PEP reactivity remained significant after controlling for rated sadness, *F*(95.12) = 9.68, *p* = .002, $\eta^2 = .09$, or anger, *F*(94.47) = 8.28, *p* = .005, $\eta^2 = .08$, as covariates. This rather speaks

[11] 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.
[12] There was 1 missing sadness rating and 2 missing anger ratings.

against the possibility that the affect primes triggered conscious feelings that in turn influenced PEP reactivity.

Task difficulty. A 2 (Choice) × 2 (Primes) ANOVA of the subjective difficulty ratings found no significant effects, *Fs*(1, 125) < 1.67, *ps* > .199, $\eta^2 < .02$. However, a one-sample *t*-test revealed that the average difficulty rating (*M* = 4.77, *SE* = 0.10) was significantly higher than the scale's midpoint (i.e., 3.5) to, *t*(128) = 12.53, *p* < .001, $\eta^2 = .55$. Accordingly, the task was experienced as difficult—as intended.

Funnel Debriefing

No participant correctly guessed the purpose of our experiment in the funnel debriefing. Only two participants (i.e., 1.5%) reported to have seen emotional faces, suggesting that 98.5% of the 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 (one in each condition).

Discussion

We interpret the present findings as lending support to our hypothesis that personal task choice can immunize against implicit sadness effects on sympathetically mediated cardiac response (reflecting effort intensity). This finding provides additional support for the action shielding model (Gendolla et al., 2021) and extends the list of the moderators of implicit affective influences on effort (Gendolla, 2015).

Cardiovascular Effects

In line with previous research on the impact of affect primes on resource mobilization during assigned difficult tasks (Chatelain et al., 2016; Freydefont et al., 2012), we found that participants to whom a cognitive task was externally assigned and who were exposed to sadness primes showed weaker PEP responses, meaning lower effort, than those who were exposed to anger primes. This was expected because the administered task was supposed to be difficult, which was supported by our verbal difficulty manipulation check. In this context, based on the IAPE model, anger primes should lead to subjectively high but still feasible task demand, and thus lead to relatively strong sympathetically mediated cardiovascular reactivity. By contrast, sadness primes should lead to excessively high subjective task demand during performance and thus low effort due to disengagement (e.g., Silvestrini & Gendolla, 2011b; Lasauskaite Schüpbach et al., 2014)—if the subjectively high necessary effort is not justified by high success incentive (e.g., Freydefont & Gendolla, 2012). The latter was not the case in our present study. Therefore, cardiovascular reactivity was expected to be low in the present sadness prime condition. Most importantly, when participants could ostensibly personally choose their task, they were shielded against the affect prime effect on effort. Consequently, PEP reactivity was relatively strong in the Chosen task condition regardless of the administered affect primes. This was expected because task choice is known to increase commitment (Nenkov & Gollwitzer, 2012), leading to relatively high justified effort (Bouzidi et al., 2022). According to the empirically well-sustained principles of motivational intensity theory (Brehm & Self, 1989), this should result in intense effort, because the task was difficult.

At the physiological level, the predicted reactivity pattern was significant for PEP. The reactivity patterns of SBP and HR were largely consistent with the tested 3:1 effort pattern but did not attain significance. This is not surprising, as PEP is the most sensitive indicator of beta-adrenergic sympathetic nervous system impact on the cardiovascular system and thus of effort (Kelsey, 2012; Wright, 1996). Importantly, the PEP responses were not accompanied by a concomitant decrease in DBP or HR. This makes it implausible to attribute the observed PEP responses to cardiac preload or vascular afterload rather than to beta-adrenergic sympathetic impact (see Sherwood et al., 1990).

Effects on Performance

We did not find significant effects of our experimental manipulations on the task performance measure. Previous studies on implicit affect reported variable results, with some noting effects on task performance (e.g., Framorando & Gendolla, 2018a; 2023; Gendolla & Silvestrini, 2010; Lasauskaite et al., 2013), while others did not (e.g., Falk et al., 2022a, 2022b; Framorando & Gendolla, 2019a; 2019b; Lasauskaite Schüpbach et al., 2014). This is, however, not surprising because effort intensity (behavioral input) and performance (behavioral output) are not conceptually identical and performance depends besides effort also, or even more, on task-related capacity and strategies (Locke & Latham, 1990). As a result, it is not likely to find strong links between effort and performance, including disengagement effects. Moreover, the absence of significant effects on task performance might also be due to the nature of the present task.

Whereas a task with continuous trials and immediate responses at the end of each trial would have allowed us to analyze reaction times and performance changes over time, our present task only allowed to calculate the percentage of correct responses right after the task. However, it had the advantage to require continuous engagement over the entire performance period. It is also of note that participants in our study performed relatively well compared to participants in similar previous challenging memory tasks, in which participants had to memorize 19 vowels (Falk et al., 2022a; Framorando & Gendolla, 2019a). However, in contrast to those previous studies, the letters to be recalled in the present study were displayed on participants' answer sheet. Apparently, this prompting facilitated their recall. Furthermore, the PEP responses and the relatively high difficulty ratings suggest that the task was challenging. It is also of note that performance is no reliable indicator of task difficulty. A task is primarily difficult because it is hard to attain a success criterion rather than because it creates poor performance outcomes. Thus, we believe that our administered task was as intended difficult.

Effects on Self-Report Measures

As for task performance, no significant manipulation effects were found on our single item difficulty measure. This is not surprising since most of our previous studies testing the effect of affect primes on effort did not report effects on post-task verbal measures of experienced task difficulty (for exceptions see Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2012b). Probably this is because the mechanisms reflecting changes in effort are not fully conscious and thus difficult to assess with self-report measures, especially with a single item measure taken after a task. In addition, Tourangeau (1999) has suggested that retrospective measures of subjective experiences suffer from a memory biases, which render post-task measures unreliable.

Our verbal affect measures did not provide evidence that the administered anger and sadness primes induced conscious feeling states, which is consistent with all our previous affect priming studies. Although null effects do not allow firm conclusions, the lack of evidence for affect prime effects on consciously experienced affect is in line with the idea of the IAPE model that affect primes do not require conscious affect to influence effort. The briefly flashed and masked affect primes were supposed to activate implicit affect—mental representations of affective states rather than consciously experienced feelings. The results of our funnel debriefing procedure further speak for the implicitness of our priming procedure. Only two participants reported having seen emotional expressions during the task. This suggests that about all participants were unaware of what was primed, implying that the present affective influences were implicit.

Theoretical Implications

The present results align with previous findings on the impact of personal choice on explicit affective influences (Falk et al., 2022a, 2022b; Gendolla et al., 2021) and other priming effects on sympathetically mediated cardiovascular reactivity. Additionally, an action choice-based shielding effect has been observed in priming cognitive conflict (Bouzidi & Gendolla, 2022, Study 2) and was recently replicated for the shielding effect of individual differences in action orientation (Bouzidi & Gendolla, 2023). Importantly, our present results extend the shielding effect from mental protection against explicit affective influences to shielding against implicitly processed affective primes, which can have effects on effort in externally assigned cognitive tasks (Gendolla, 2012, 2015). Correspondingly, in our present study, the implicit affect prime effect on sympathetically mediated cardiac response was only evident when participants worked on an externally assigned task. Most relevant, when participants could ostensibly choose their task, the implicit affect primes' effect disappeared. This aligns with another recent study by Framorando et al. (2023), in which personal task choice attenuated the effect of fear primes on PEP reactivity in an easy task. However, in that study the manipulation effects were limited to the beginning of the task. Our present effects for a difficult task are more conclusive.

Future research may test if only task choice (and a high action orientation) or also other factors can have affect shielding effects on effort. One candidate is mental contrasting, a self-regulation strategy where individuals engage in action by mentally contrasting the desired future with the obstacle of reality, which has proven to be beneficial for creating strong goal commitment with subsequent goal striving and goal attainment (Oettingen, 2012; Oettingen et al., 2001). Another is planning out in advance how one wants to deal with unwanted affective influences during one's goal striving by making respective if-then plans (Gollwitzer, 1999). Such plans can target the critical affect (e.g., "when anger is coming up, then I will ignore it") or spell out the task to be performed in terms of if-then steps (e.g., "when I have finished the first part of the task, then I will immediately move on to the second part"). Research has demonstrated that both types of plans are successful in shielding goal striving from affective influences, no matter whether these are processed with much conscious elaboration or not (Achtziger et al., 2008; Bayer et al. 2010; Gollwitzer et al., 2011).

From a broader perspective, the current study has also significant implications for research on automaticity. It has been posited that unconscious influences on behavior cannot be controlled (Bargh & Chartrand, 1999). This leads individuals to generally dislike implicit influences because they reduce their sense of control, agency, and autonomy (Bandura, 1986, 2001; Brehm, 1966; Loersch & Payne 2012; Ryan & Deci, 2000). Fortunately, research has shown that individuals can protect themselves from implicit influences by being aware of the source of the information (e.g., the primes) or being informed of being primed (e.g., Framorando & Gendolla, 2018a, 2018b, 2019a; Vewijmeren et al., 2013). The present study extends the list of identified boundary conditions of automaticity. Our results show that giving people the opportunity to choose their tasks can shield them against implicit influences during action execution. Accordingly, implicit priming effects may be more controllable than often suggested (see also Bargh & Chartrand, 1999).

Limitations

It may be argued that our tested 3:1 contrast may not fully explain the impact of implicit affect primes on effort in both chosen and assigned task conditions. One might assume that sympathetically mediated cardiovascular responses in the anger-prime/assigned-task condition (slightly lower task demand due to retrieved ease-related information) should be somewhat weaker than in the anger-prime/chosen-task condition (high justified effort and slightly higher task demand due to the shielding effect of task choice against affective influences). This would largely but not perfectly align with the predicted, tested, and found 3:1 effort pattern. However, on the operational level, it is hard to predict in how much the anger-prime/assigned-task condition should differ from its counterpart in the chosen task condition in a measurable way and to model that appropriately. We were confident to predict that effort should be relatively high in both anger primes conditions, meaning that the 3:1 pattern is the closest to our hypotheses. Alternative contrasts would correspond to the predicted effort pattern less well. That is, even though one might see some imperfection in the tested 3:1 contrast, that pattern comes the closest to the predicted effects. It is of note that additional cell comparisons provided clear support for the 3:1 pattern. Moreover, Falk et al. (2022a) reported corresponding findings regarding the effects of shielding against happy vs. sad background music on PEP reactivity in an objectively difficult task.

Relatedly, it may be argued that the results of our present experiment do not provide strong support for a shielding effect of task choice on anger primes because both the Chosen Task and Assigned Task conditions exhibited similar PEP responses. However, this finding might be due to different reasons, as outlined in detail above. In a task of unfixed difficulty in which participants do their best instead of trying to attain a fixed performance standard, anger or happiness primes should lead to different effort levels in assigned and personally chosen tasks. If the unfixed difficulty task is assigned, anger or happiness primes should lead to lower effort intensity than sadness or fear primes (see Gendolla & Silvestrini, 2011). This is because anger and happiness primes should make the concept of ease accessible in the Assigned Task condition, resulting in lower subjective demand and thus lower effort when task demand is unfixed. Conversely, sadness or fear primes should make the concept of difficulty accessible, resulting in higher subjective task demand and higher effort. In the Chosen Task conditions, the higher commitment resulting from personal task choice should justify high effort (e.g., Bouzidi et al., 2022) and lead to relatively high effort levels when task difficulty is unfixed (e.g., Gendolla & Richter, 2005, 2006; Gendolla et al., 2008). This consideration aligns with previous research supporting the principles of motivational intensity theory for tasks of unfixed difficulty. Still, further research is needed to fully understand the impact of task choice on performance using different task demands and affective influences. Nevertheless, the present findings advance the understanding of moderators and boundary conditions of affect priming, as they reveal the particularly strong power of personal choice in action control.

Conclusion

The present experiment extends the evidence for the action shielding model (Gendolla et al., 2021) by showing that personal task choice shields not only against explicit but also implicit affective influences on sympathetically mediated cardiac response. Importantly, our study represents the first empirical evidence that personal task choice can protect against implicit affective influences on sympathetically mediated cardiac response in a difficult cognitive task. Thereby, this finding contributes to the understanding of the complex interplay between personal choice, affective influences, and effort-related cardiovascular responses. It also helps to uncover the underlying mechanisms involved in the shielding effect suggesting that choosing along personal preferences can serve as a protective mechanism against a variety of external influences—even influences that are not consciously processed. Even though our research highlights the robustness of the shielding effect, it should be noted that the effect of task choice on the anger primes’ impact on effort still needs further confirmation and extension (e.g., by using tasks where participants can set their own performance standard—see Richter et al., 2016).

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Supplemental Material

The Power of Personal Control: Task Choice Attenuates the Effect of Implicit Sadness on Sympathetically Mediated Cardiac Response During Task Performance

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Cardiac output (CO) and total peripheral resistance (TPR) were also analyzed to provide interested readers with a more comprehensive picture of the hemodynamic responses during task performance, although neither measure was relevant for our hypotheses. One participant was excluded from the analysis because of excessive CO and TPR reactivity (> 3 *SD*s than condition *M*s). 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 (Primes) 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 (ωs > .98). 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* > .514).[13]

Supplemental Table S1

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

	Chosen Task		Assigned Task	
	Sadness Primes	Anger Primes	Sadness Primes	Anger Primes
CO	5.48 (0.14)	5.40 (0.17)	5.43 (0.17)	5.30 (0.13)
TPR	1138.21 (35.44)	1149.99 (32.24)	1156.49 (37.97)	1163.70 (28.42)

Note: CO = cardiac output (in liters per minute), TPR = total peripheral resistance (in dynes second per centimeter to the 5th power). *N* = 128 for both measures.

CO and TPR Reactivity

We created cardiovascular reactivity scores by subtracting participants' baseline scores from the averaged values of the five 1-min CO and TPR values that were assessed during task performance and which showed high internal consistency (ωs > .99). Means and standard errors are shown in Supplemental Table S2.

[13] The 3:1 contrast that tested our predictions about cardiovascular reactivity was not significant for any of the CO and TPR baseline values (*ps* ≥ .851). For readers interested in gender differences, we also compared the cardiovascular baseline values of women and men, which did not reveal any significant difference for baseline values of CO or TPR (*ps* ≥ .119).

CO Reactivity. A 2 (Choice) × 2 (Primes) ANOVA of CO reactivity revealed neither significant main effects nor an interaction effect (*ps* ≥ .159). Also the 3:1 effort contrast was not significant (*p* = .407).[14]

TPR Reactivity. According to a 2 (Choice) × 2 (Primes) ANOVA of TPR reactivity, there were no significant effects (*ps* > .468). The 3:1 a priori effort contrast was also not significant (*p* = .508).

Supplemental Table S2

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

	Chosen Task		Assigned Task	
	Sadness Primes	Anger Primes	Sadness Primes	Anger Primes
CO	0.34 (.07)	0.22(0.68)	0.23 (0.41)	0.28 (0.04)
TPR	1.19 (13.53)	11.69 (12.27)	16.68 (10.54)	9.87 (10.50)

Note: CO = cardiac output (in liters per minute), TPR = total peripheral resistance (in dynes second per centimeter to the 5th power). *N* = 128 for both measures.

Supplemental References

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[14] According to Levene test, the variances significantly differed between the conditions (*p* = .01). Therefore, we reported the *p*-value of the contrast test that does not assume equal variances.

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Impact Statement

The Power of Personal Control: Task Choice Attenuates the Effect of Implicit Sadness on Sympathetically Mediated Cardiac Response

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This study extends evidence on the action-shielding model to affect prime effects on sympathetically mediated cardiovascular response. Personal task choice could shield against the effect of implicitly processed sadness primes on sympathetically mediated cardiac response that were evident when the task was assigned. Importantly, the present study also adds to the list of moderators for implicit affective influences on effort. The results suggest that implicit priming is less automatic and uncontrollable as previously thought.