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# Incidental affective influences on effort-related cardiac response: The critical role of choosing task characteristics☆

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ABSTRACT

This experiment tested whether personal choice vs. external assignment of task characteristics moderates the effect of incidental affective stimulation on effort-related cardiovascular response. We expected strong action shielding and low receptivity for incidental affective influences when participants could choose themselves the stimulus color of an easy memory task. By contrast, when the stimulus color was assigned, we expected weak action shielding and high receptivity. As expected, participants in the assigned color condition showed stronger cardiac pre-ejection period reactivity when exposed to sad music than when exposed to happy music during task performance. These music effects did not appear among participants who could personally choose the stimulus color. Our results replicate previous research by showing that personal choice leads to action shielding, whereas individuals remain receptive for affective influences during volition when task characteristics are assigned.

## 1. Introduction

There is ample evidence that affective experiences systematically influence effort-related responses in the cardiovascular system (see Gendolla and Brinkmann, 2005; Gendolla et al., 2012, for reviews). However, there is reason to believe that the way people engage in a task—by deliberation and choice vs. external assignment—moderates the impact of incidental affective stimulation on effort.

According to theorizing and research on volition—the execution, maintenance, and protection of goal-directed action (Kuhl, 1986)—intention formation leads to an implemental mindset where multiple cognitive processes facilitate successful action execution (Gollwitzer, 1990; Heckhausen and Gollwitzer, 1987). After committing to a goal or action, individuals enter a specific mindset that facilitates determined goal striving through heightened task focus and strong action shielding. Through action shielding, goal pursuit is protected against potentially conflicting influences, including incidental affective stimuli (e.g., Gollwitzer, 1993; Gollwitzer and Bayer, 1999). The action shielding effect has been empirically supported: in the presence of conflicting goals, the commitment to the focal goal shields the individual against alternative goals (Shah et al., 2002). However, a further line of research looking at the influence of affective states on goal pursuit posits affect as a factor that systematically influences volition. Strong evidence supports the idea that affect systematically influences goal pursuit in terms of both effort intensity (see Gendolla, 2012; Gendolla et al., 2012) and behavioral persistence (see Martin, 2001; Martin and Stoner, 1996)—two core markers of volition.

In a first step to integrate these lines of research in terms of an action shielding model, task choice versus task assignment was found to be a moderating variable of the effect of incidental affective stimulation on volition (Gendolla et al., 2021). Participants assigned to a cognitive task showed lower persistence (Study 1) and lower effort assessed as cardiac pre-ejection period (Study 2) when exposed to happy music as compared with sad music. Importantly, these effects did not appear among participants who could ostensibly choose the task to perform. Another study demonstrated the effort shielding effect in an objectively difficult task

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(Falk et al., 2022).

The present study aimed at extending this research evidence by applying a different experimental procedure to vary participants' feelings of choice. In the frame of the new choice manipulation, participants made a real choice of task characteristics instead of an ostensible choice of the type of task, as in the studies by Gendolla et al. (2021) and Falk et al. (2022).

### 1.1. Affective influences on effort

Numerous studies in the context of the Mood-Behavior-Model (MBM; Gendolla, 2000) have shown systematic external affective influences on effort-related cardiovascular response (see Gendolla and Brinkmann, 2005; Gendolla et al., 2012 for reviews). The MBM posits that mood states influence effort primarily through their informational value for behavior-related judgments. Such judgments are more positive in a happy mood than in a sad mood. The integration with theoretical assumptions on resource mobilization allows for specific and context-dependent predictions about effort.

According to the motivational intensity theory (Brehm and Self, 1989), individuals avoid investing more resources than necessary. Accordingly, effort rises proportionally with experienced task difficulty, but only as long as success is possible and the required effort is justified by the importance of success. Following this principle, effort is low when a task is subjectively easy, moderate when the task feels moderately difficult, and high when the task is experienced as difficult but feasible. Only when task demand exceeds the person's ability, or when the amount of necessary effort is not justified by the importance of task success, individuals should avoid wasting their resources and disengage. Over the last decades, these predictions have found strong empirical support through cardiovascular measures of effort (see Gendolla et al., 2012, 2019; Richter et al., 2016; Wright and Kirby, 2001, for reviews).

The Mood-Behavior-Model posits that subjective task difficulty is influenced by individuals' current mood. When confronted with a task, mood and information about objective task difficulty are integrated into demand appraisals. In an objectively easy task, a sad mood thus leads to a higher perceived difficulty than a happy mood, and consequently to higher effort (e.g., Gendolla and Krüsken, 2001a, 2001b, 2002a). In objectively difficult tasks the mood effect on effort turns around. Here, a sad mood leads to very high experienced task demand and thus to disengagement if the high required effort is *not* justified by high success importance (e.g., because of high success incentive). By contrast, a happy mood results in relatively high subjective demand and thus relatively high effort (e.g., Gendolla and Krüsken, 2001a, 2002b). However, if a high incentive justifies high effort, sad mood can lead to very high effort (e.g., Gendolla and Krüsken, 2002c; Silvestrini and Gendolla, 2009). That is, mood's effect on effort-related cardiovascular response is context-dependent and moderated by objective task difficulty and success importance. Importantly, these systematic mood effects have always been studied in assigned task settings—the default procedure in psychological experiments.

### 1.2. Action shielding: an integrative approach

To define under which circumstances affective influences take effect on action execution and to align the two research lines which have been studied in isolation from each other, we have suggested an integrative action shielding model (Gendolla et al., 2021). Accordingly, the personal choice of tasks or task characteristics moderates the well documented effects of incidental affective influences on volition (see Gendolla and Brinkmann, 2005; Martin, 2001). Based on the idea that choice fosters strong commitment (Bouzidi et al., 2022) and action shielding (Gollwitzer, 1990; Heckhausen and Gollwitzer, 1987), it seems reasonable to assume that choice of task characteristics should minimize incidental affective influences on effort. Correspondingly, external assignment of tasks characteristics should be associated with lower commitment, a weaker implemental mindset, weaker task focus, weaker action shielding, and thus stronger affective influences on action execution—as documented in many studies in which tasks and their characterisitcs were externally assigned (see Gendolla et al., 2012; Martin, 2001).

The present study aims at replicating first evidence that supports this integrative action shielding model on the moderating role of deliberation (Falk et al., 2022; Gendolla et al., 2021) by further testing the action shielding hypothesis in the context of an easy task. This time, we applied a different choice manipulation: participants could choose task characteristics—the color of task stimuli—rather than the type of an upcoming task. This choice manipulation allows us to test if the previously observed shielding effect is limited to ostensible choices of the type of task or extends to the real choice of task characteristics as well.

### 1.3. Effort-related cardiovascular response

Effort is defined as the mobilization of resources during goal pursuit (Gendolla and Wright, 2009). Based on Wright's (1996) integration of motivational intensity theory (Brehm and Self, 1989) with considerations about psychophysiological responses in active coping situations (Obrist, 1981), effort intensity can be operationalized by indicators of beta-adrenergic sympathetic impact on the heart. The sympathetic innervation of the heart affects two main parameters of cardiac performance: the contraction pace and the contractile force of the heart muscle (Levick, 2010). Because the heart's pace depends on the independent impacts of both sympathetic and parasympathetic activity, heart rate (HR) is not an ideal indicator of effort. By contrast, the heart's contractile force depends only on beta adrenergic sympathetic impact (Richter et al., 2016; Wright, 1996). Cardiac pre-ejection-period (PEP)—the time interval between the onset of ventricular depolarization and the opening of the aortic valve—is a direct indicator of myocardial contractile force (Berntson et al., 2004) and thus an ideal effort index (Kelsey, 2012; Wright, 1996). Stronger beta-adrenergic sympathetic impact results in shorter PEP.

Because of its link with cardiac contractile force, many studies have operationalized effort as performance-related changes in systolic blood pressure (SBP; the maximum pressure in the vascular system between two consecutive heart beats, see Gendolla et al., 2012; Richter et al., 2016, Wright and Kirby, 2001, for reviews). But beside beta-adrenergic sympathetic impact, SBP is also influenced by peripheral vascular resistance, which is not systematically influenced by beta-adrenergic impact. The influence of vascular resistance on diastolic blood pressure (DBP; the minimal pressure in the vascular system between two consecutive heart beats) is even stronger.

In summary, PEP is the purest indicator of beta-adrenergic sympathetic impact and thus the most reliable and valid measure of effort (Kelsey, 2012; Wright, 1996). However, PEP should always be assessed together with HR and blood pressure to monitor possible effects of ventricular filling and arterial pressure on PEP (Sherwood et al., 1990).

### 1.4. The present research

We ran an experiment to test our conceptual hypothesis that affective influences on effort-related cardiovascular response should be relatively strong when task characteristics are assigned, but weak due to stronger action shielding when task characteristics are self-chosen. Half the participants could choose one of four colors in which the stimuli of an easy memory task would be displayed, based on their preference. The other half of the participants were asked to perform the task with a given stimulus color—the color that was selected by their yoked participant in the Chosen Color condition. All participants worked on the same task, in which they were continuously presented with different letter series consisting of vowels and consonants. Their task was to memorize how often the letter “A” appeared in the presented series of letters and to report the correct number at the end of the task. During task performance, all participants were exposed to the incidental external affective stimulation: half of the participants were exposed to happy background music, while the other half was exposed to sad music. Success importance was generally modest in our experimental setting (participants received no performance-contingent incentive).

Our predictions and the logic behind them were the same as in Study 2 by Gendolla et al. (2021): We expected the music to influence effort-related cardiovascular reactivity, especially PEP, in the Assigned Color condition, but not in the Chosen Color condition. Given that the cognitive task was easy, we predicted relatively strong PEP reactivity in the Assigned Color/Sad Music condition, and relatively low PEP reactivity in the other three conditions (Assigned Color/Happy Music, Chosen Color/Sad Music, Chosen Color/Happy Music). We expected this pattern because mood has an informative function resulting in mood congruency-effects on demand appraisals. Experienced demand is higher in a sad mood than in a happy mood (e.g., Gendolla et al., 2001), and it informs the individual about the necessary amount of effort. By contrast, participants in the Chosen Color condition should be shielded against the music influence on effort, leading to relatively weak PEP responses in both music conditions. This is because without the mood congruency effect on subjective demand, the easy cognitive task only necessitates low effort. Effort in the Chosen Color condition should only be high when a task is objectively difficult, because high difficulty leads to high effort when the latter is justified (Brehm and Self, 1989). By contrast, an easy task only necessitates low effort—if affective influences are neutralized. Altogether, this results in the prediction of a 3:1 pattern of cardiovascular reactivity (especially PEP), with stronger responses in the Assigned Color/Sad Music condition than in the other three conditions.

Since effort intensity (behavioral input) and performance (behavioral output) are not conceptually identical and performance depends besides effort also, or even more, on task-related ability and strategies (Locke and Latham, 1990), we did not predict the effort pattern to be reflected in the participants' performance.

## 2. Methods

### 2.1. Participants and design

Previous research applying the present music manipulation and a comparable choice manipulation has found significant effects of medium size on resource mobilization measures with samples of 20–31 participants per condition (Falk et al., 2022; Gendolla et al., 2021). To have a comparable sample size, we aimed at collecting data of 30 participants per condition. In total, 124 undergraduate psychology students were randomly assigned to our 2 (Choice) x 2 (Music) between-persons experimental design. However, due to technical issues during the testing procedure, data sets of 7 participants had to be removed from the analyses. Thus, the final sample consisted of $N = 117$ participants (91 women, 25 men; average age 21 years)[1] with the following numbers of participants in the four conditions: Chosen Color/Happy Music (28 participants), Chosen Color/Sad Music (29 participants), Assigned Color/Happy Music (29 participants), Assigned Color/Sad Music (31 participants). According to a sensitivity analysis run with G*power (Faul et al., 2007), our sample size was sufficient to detect significant a priori contrast effects as well as ANOVA main and interaction effects of a medium size with 80% power in our 2 × 2 factorial design.

### 2.2. Physiological measures

The Cardioscreen 1000 system (medis, Imenau, Germany) was used to noninvasively record (sampling rate 1000 Hz) electrocardiogram (ECG) and thoracic impedance signals (ICG), from which we derived cardiac PEP and HR. Two pairs of single-use electrodes (Ag/AgCI; medis, Imenau, Germany) were used: one dual sensor was attached to the left side of the base of the participants' neck, and two single sensors were placed on the participants' chest (left middle axillary line at the height of the xiphoid). We used BlueBox 2.V1.22 software (Richter, 2010) for data processing. R-peaks were automatically identified using a threshold peak detection algorithm and visually confirmed, allowing to determine HR (in beats/min). The first derivative of the change in thoracic impedance was calculated, and the resulting dZ/dt signal (low-pass filtered at 50 Hz) was ensemble averaged over 1-min periods, based on the detected R-peaks. B-point location was estimated based on the RZ interval of valid heart beat cycles (Lozano et al., 2007), visually checked and manually corrected (Sherwood et al., 1990), to determine PEP (in ms; interval between R-onset and B-point; Berntson et al., 2004).

Systolic (SBP) and diastolic blood pressure (DBP; both in mmHg) were oscillometrically assessed in 1-min intervals with a Dinamap ProCare monitor (GE Healthcare, Milwaukee, WI). A blood pressure cuff was placed over the brachial artery above the elbow of participants' non-dominant arm. The cuff inflated automatically in 1-min intervals and assessed values were stored by the monitor.

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 Supplementary Online Material.

### 2.3. Procedure

All procedures and measures were approved by the local Ethics Committee. The experiment was run with E-Prime 3.0 (Psychology Software Tools, Sharpsburg, PA) and advertised as a 30-min study on cardiovascular activity during cognitive task performance. A hired experimenter conducted all laboratory testing sessions and was unaware of both the hypotheses and experimental conditions. Upon arrival, participants were welcomed, seated in a comfortable chair in front of a computer, and provided with written informed consent. The experimenter attached the physiological sensors, started the experimental software, and went to an adjacent control room.

First, participants rated 2 negative (down, sad) and 2 positive affect items (happy, joyful) of the UWIST mood scale (Matthews et al., 1990) on continuous rating scales (1 = *not at all,* 100 = *very much*) to assess mood baseline values. Ratings were made using a slider. Its default position was fixed mid-scale and could be pushed towards the extremes by pressing the left and right arrow keys on the computer keyboard. To prevent suspicion, these affect ratings were introduced as standard measures, because of potentially different feeling states of participants entering the laboratory. Next, cardiovascular baseline values were assessed during the presentation of a hedonically neutral 8-min long film about Portugal.

After the habituation period, participants in the Chosen Color condition learned that they could now choose one of four colors in which the stimuli of an upcoming memory task would be displayed, based on their preference. To give participants a reason for their choice and to assure some relevance of the choice, they read: “Current research results show that the possibility of choosing a stimuli color has a positive effect on task performance”. After participants had pressed “enter” to continue, examples of the stimuli colors (red, blue, green, yellow) were provided on the next screen. The following screen asked participants to deliberate for 1-min on the question “Which stimuli color do you prefer?” Participants started that period by pressing “enter”. After 1 min, participants were asked to indicate their choice by pressing one of the four corresponding keys indicated on the display. Next, the chosen color was once

[1] The gender distributions were balanced in all four conditions: Chosen Color/Happy Music (22 women/6 men), Chosen Color/Sad Music (24 women/5 men), Assigned Color/Happy Music (22 women, 7 men), and Assigned Color/Sad Music (23 women/7 men). Not surprisingly, a chi-square test of these frequency distributions was nowhere near significance ($p = .921$).

again displayed, and accompanied by the question "Are you sure about your choice?" to assure participants' commitment to the chosen color. If they pressed the green key for "yes", the procedure continued; if they pressed the red key for "no", the stimuli colors were once again presented and participants had to indicate their choice again. The procedure then continued after entering and confirming their decision.

In the Assigned Color condition, participants worked on the task in the color chosen by their yoked participant in the Chosen Color condition. As an example, if the yoked participant previously chose the stimuli color blue, participants read "Current research results show a positive effect on task performance when the task stimuli are displayed in blue". To create similar conditions to the Chosen Color condition, Assigned Color participants were then asked to take a 1-min break before the task instructions were displayed. Then, all participants rated the following question: "To what extend could you decide the characteristics of the task to perform?" Answers were given with a slider on a continuous scale ranging from 1 (*not at all*) to 100 (*very much*).

All participants worked on the same cognitive task and were presented with 39 different 4-letter series (e.g., "APTI", "BRUR"). The participants were instructed to count the exact number of appearances of the letter "A" during the entire task and to indicate the frequency of the letter "A" at the end of the task. The task took 5 min, and in total, the assemblies of letters contained 7 times the letter "A". Each trial started with a fixation cross (750 ms), followed by a series of 4 letters (4 s) and an intertrial interval that randomly varied between 2 and 4 s. During task performance, participants were presented with a randomized order of the letter series while cardiovascular activity was assessed. Before the main task, all participants performed 5 practice trials (LPCW – MALP – LRPQ – LZIC – LAVM) to familiarize themselves with the task. The correct number of presented "A"s (A = 2) was displayed at the end of the practice, allowing the participants to check their responses.

Before starting the main task, instructions were once again displayed as a reminder, and participants were informed about the presentation of background music during the upcoming main task. Participants in the Happy Music condition were exposed to Vivaldi's elating "Le quattro stagioni, Op. 1 Allegro", and in the Sad Music condition to the depressing piece "The coup" by Hans Zimmer from the movie "The House of Spirits". These pieces of music have efficiently induced happy and sad mood states in previous research (e.g., Gendolla et al., 2021, Study 1; Gendolla and Krüsken, 2001a, 2001b) and were presented in moderate background volume. The music presentations started 15 s before the first task trial.

After the task, participants rated subjective task difficulty on a continuous scale ("To what extend did you find the task difficult?"), ranging from 1 *(not at all)* to 100 *(very difficult)*. Next, participants rated the same mood items presented at the procedure's beginning and answered additional questions about their gender, first language, French language proficiency, and medication use. The experiment ended with a short debriefing and the possibility to discuss one's personal experience of the procedure with the experimenter. Importantly, no participant guessed the purpose of the study or questioned the choice or music manipulations.

## 3. Results

We performed a priori contrast analyses to test our expected 3:1 interaction pattern with relatively strong effort-related cardiovascular responses (especially PEP) in the Assigned Color/Sad Music condition (contrast weight + 3) and weaker reactivity in the other three conditions (contrast weights −1). A priori contrasts are the most powerful and thus appropriate statistical tool to test hypotheses about predicted patterns of means (Rosenthal and Rosnew, 1985; Wilkinson and The Task Force on Statistical Inference of APA, 1999). Variables for which we had not specified theory-based predictions were analyzed with conventional exploratory 2 × 2 between persons ANOVAs.

### 3.1. Cardiovascular baselines

We had a priori decided to constitute baselines by averaging cardiovascular values of the last 3 min of the habituation period because cardiovascular baseline values generally become stable towards the end of a habituation period. The cardiovascular measures showed high internal consistency during the last 3 min (Cronbach's $\alpha s \geq 0.91$). Cell means and standard errors of the baseline scores appear in Table 1. Preliminary 2 (Choice) x 2 (Music) ANOVAs revealed no significant differences between the later conditions ($ps \geq 0.233$).[2]

### 3.2. Cardiovascular reactivity

We created reactivity scores (Llabre et al., 1991) by subtracting the baseline values from the five 1-min values of PEP, HR, SBP, and DBP that were assessed during task performance. The 5 change scores for each measure showed high internal consistency (Cronbach's $\alpha s \geq 0.85$) and were averaged. Preliminary analyses of covariance (ANCOVAs) of the averaged cardiovascular reactivity scores with the respective baseline scores only found a significant association between the HR baseline and reactivity scores, $F(1,112) = 4.27$, $p = .041$, $\eta^2 = 0.04$. Therefore, we further analyzed baseline-adjusted reactivity scores of HR to prevent possible carryover or initial values effects. No significant associations emerged between baseline and reactivity scores of PEP, SBP, and DBP ($ps \geq 0.156$).

#### 3.2.1. PEP reactivity

In line with our hypothesis, our theory-based a priori contrast for PEP reactivity—our primary effort-related measure—was significant and had a medium effect size, $F(1,113) = 6.68$, $p = .011$, $\eta^2 = 0.06$. As depicted in Fig. 1, the PEP responses showed the predicted 3:1 pattern (note that decreases in PEP are reflecting increases in effort intensity). Additional cell contrasts revealed that PEP reactivity in the Assigned Color/Sad Music condition ($M = -1.96$, $SE = 0.48$) was significantly stronger than in the Chosen Color/Happy Music ($M = -0.76$, $SE = 0.39$), the Chosen Color/Sad Music ($M = -0.71$, $SE = 0.54$) and the Assigned Color/Happy Music ($M = -0.40$, $SE = 0.38$) conditions, $ts(113) \geq 1.86$, $ps \leq 0.033$, $\eta^2s > 0.03$, which in turn did not significantly differ from one

**Table 1**
Means and Standard Errors (in parentheses) of the Cardiovascular Baseline Values.

| | Chosen color | | Assigned color | |
|---|---|---|---|---|
| | Happy music | Sad music | Happy music | Sad music |
| PEP | 101.71 (2.98) | 104.11 (2.65) | 99.57 (2.73) | 102.99 (2.73) |
| SBP | 102.75 (1.39) | 103.66 (1.27) | 106.24 (1.60) | 103.71 (1.58) |
| DBP | 57.96 (0.71) | 57.93 (0.88) | 58.05 (0.68) | 57.60 (0.90) |
| HR | 81.37 (2.86) | 77.95 (2.46) | 79.94 (2.09) | 78.62 (2.51) |

Note. PEP = pre-ejection period (in ms), SBP = systolic blood pressure (in mmHg), DBP = diastolic blood pressure (in mmHg), and HR = heart rate (in beats/min). $N = 117$ for all measures.

[2] The 3:1 contrast that tested our predictions about cardiovascular reactivity was not significant for any of the cardiovascular baseline values ($p \geq .679$). For readers interested in gender differences in cardiovascular activity, we compared the baseline values of women and men with *t*-tests (including gender in three-factorial ANOVAs did not make sense because there were far more women than men in our sample). The analyses revealed significant gender differences for baseline values of SBP $t(114) = 5.59$, $p = .001$, $\eta^2 = 0.22$, due to higher SBP for men ($M = 111.17$, $SE = 1.64$) than for women ($M = 102.26$, $SE = 0.70$). No other cardiovascular measures showed significant gender differences for baseline values ($ps \geq 0.340$). Further, gender had no significant main effects on cardiovascular response ($ps \geq 0.105$).

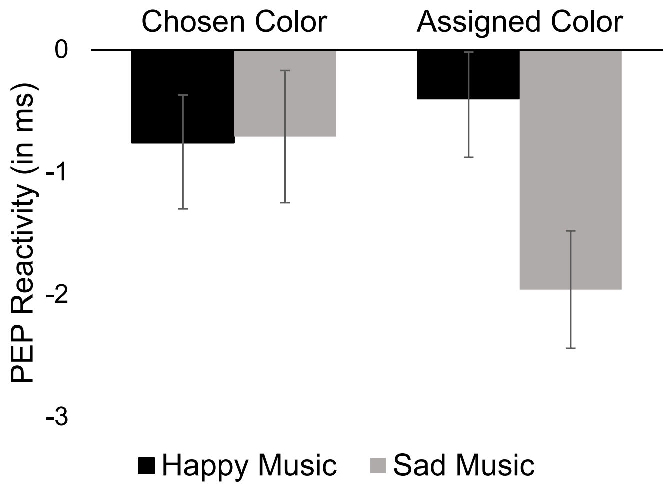


**Fig. 1.** Cell means and ± 1 standard errors underlying the combined effect of Color Choice and Music on cardiac pre-ejection period (PEP) reactivity during task performance.

another (*ps* ≥ 0.511). This fully confirms our predictions.[3]

### 3.2.2. HR and blood pressure reactivity

The a priori contrasts for HR, SBP, and DBP were not significant, $Fs(1, 113) \leq 2.76$, $ps \geq 0.099$, although the response patterns of all three measures largely corresponded to the predicted 3:1 pattern. Cell means and standard errors appear in Table 2.

## 3.3. Task performance

Overall, 91% of the participants indicated the correct response. This high percentage of correct answers supports our assumption that the task was as intended easy. A *chi-square* test did not reveal a significant difference in the frequency distributions of correct responses between the experimental conditions ($p = .236$).

## 3.4. Verbal measures

### 3.4.1. Choice

A 2 (Choice) x 2 (Music) ANOVA of the verbal choice manipulation check revealed a strong significant Choice main effect, $F(1, 113) = 23.75$, $p < .001$, $\eta^2 = 0.17$. Participants in the Chosen Color condition ($M = 50.25$, $SE = 3.57$) rated their freedom to choose the task characteristics as significantly higher than those in the Assigned Color condition ($M = 24.70$, SE = 3.73). Other effects were not significant ($ps > 0.244$).

**Table 2**
Means and standard errors (in parentheses) of the cardiovascular reactivity scores.

| | Chosen color | | Assigned color | |
|---|---|---|---|---|
| | Happy music | Sad music | Happy music | Sad music |
| SBP | 1.99 (0.56) | 1.90 (0.66) | 2.03 (0.67) | 3.16 (0.62) |
| DBP | 1.46 (0.47) | 1.43 (0.46) | 1.53 (0.55) | 2.26 (0.39) |
| HR | 1.28 (0.75) | 1.07 (0.64) | 1.83 (0.58) | 2.25 (0.55) |

Note. SBP = systolic blood pressure (in mmHg), DBP = diastolic blood pressure (in mmHg), and HR = heart rate (in beats/min). $N = 117$ for all measures.

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

### 3.4.2. Mood

We created pre-task and post-task affect scores by summing the happiness and the reversed sadness ratings at both times of measurement. Descriptively, the mood change scores corresponded to the intended mood manipulation: Mood changes were negative in the Sad Music condition ($M = -3.45$, $SE = 5.29$), but positive in the Happy Music condition ($M = 6.89$, $SE = 5.46$). However, a 2 (Choice) x 2 (Music) ANCOVA of the mood change scores with pre-test mood scores as covariate revealed no significant main or interaction effects, $Fs(1, 112) \leq 0.56$, $ps \geq 0.456$. Only the covariate effect was significant, $F(1, 112) = 8.62$, $p = .004$, $\eta^2 = 0.07$.

### 3.4.3. Difficulty

A 2 (Choice) x 2 (Music) ANOVA of participants' task difficulty ratings revealed no significant main or interaction effects, $F(1, 113) \leq 0.54$, $p \geq .46$. Generally, the difficulty ratings ($M = 12.09$, $SE = 1.83$) were significantly lower than the scale's midpoint (50.00) according to a one-sample *t*-test, $t(116) = 20.75$, $p < .001$, $\eta^2 = 0.79$. This indicates that the task was perceived as easy by the participants.

# 4. Discussion

The present study further supports our action shielding model and conceptually replicates first evidence that personal choice shields against incidental affective influences on effort-related cardiac response in the context of a relatively easy task (Gendolla et al., 2021). Consistent with previous findings on mood effects on effort-related cardiovascular response during the performance of assigned tasks (e.g., De Burgo and Gendolla, 2009; Gendolla et al., 2001; Gendolla and Krüsken, 2001a, 2002a, 2002b), participants in the present Assigned Color condition showed significantly stronger reactivity when exposed to sad background music than when exposed to happy music. We had expected this because although our task required continuous attention, it was not very demanding and thus experienced as easy—which was supported by both participants' performance data and task difficulty ratings. In this easy task context, the happy music was expected to lead to a subjectively low and feasible task demand during performance and thus low effort. The sad music should add difficulty to the perceived task demand, resulting in higher effort than the exposure to happy music. Our results confirmed these predictions. Consequently, in the setting of the Assigned Color, our results replicate previous studies (see Gendolla and Brinkmann, 2005; Gendolla et al., 2012 for overviews).

Further, when participants deliberated and subsequently chose their preferred task color, effort-related cardiac responses showed no evidence for music influences. Here, PEP reactivity was modest in general, because the objectively low demanding task did not necessitate more effort when participants were protected against incidental affective influences. In accordance with the many studies supporting the principles of motivational intensity theory (Brehm and Self, 1989; see Gendolla et al., 2012, 2019; Richter et al., 2016; Wright and Kirby, 2001 for reviews), effort was low in general, because the easy task did not ask for more—even though commitment to succeed should have been relatively high due to the personal choice of task characteristics (e.g., Bouzidi et al., 2022). Overall, our main result replicates first evidence for the shielding effect of choice (Falk et al., 2022; Gendolla et al., 2021) by supporting the hypothesis that engaging in actions based on personal choice versus external assignment moderates the effect of incidental affective stimulation on effort-related cardiac response. This further speaks for the validity of our integrative action shielding model (Gendolla et al., 2021).

On the physiological level, the predicted reactivity pattern was significant (with a medium effect size) for our main effort-related measure—PEP reactivity. This was expected because PEP is the most sensitive measure of beta-adrenergic sympathetic impact on the heart and thus of effort (Kelsey, 2012; Wright, 1996). Reactivity patterns of SBP, DBP, and HR largely corresponded to the expected 3:1 pattern, but no significant effects were observed. This is, however, not surprising, because PEP is a more reliable and valid measure of beta-adrenergic impact than the other assessed cardiovascular activity parameters. There were also no significant manipulation effects on task performance. Also this is not surprising–we did not expect differences in effort-related cardiovascular response to be reflected by performance. The link between effort and performance is difficult to predict: effort intensity (behavioral input) and performance (behavioral output) are not conceptually identical and performance depends besides effort also, or even more though, on task-related ability and strategies (Locke and Latham, 1990). However, participants' overall high performance supports our assumption that we successfully created a low demanding task, as further supported by our verbal measure of task difficulty.

Our choice manipulation check revealed a highly significant effect on participants' feelings of having control over the characteristics of the task they worked on. In addition to the verbal check, participants also experienced the consequence of their choice during the task: the stimuli appeared in the chosen color. Contrary to the color choice manipulation, participants in previous task choice manipulation (Falk et al., 2022; Gendolla et al., 2021) ostensibly got to choose between two different types of tasks (memory task vs. attention task), but were working on the same cognitive task in the end. Our present color choice manipulation has the advantage of containing real consequences that are experienced by the participants and thus allowed us to extend the previous findings. Similar to the previous experimental procedure, participants received information about the consequences of personally choosing task characteristics, and a fixed deliberation period of one minute. This specific procedure allows to strengthen the importance of personal choice and ensures a successful induction of an implemental mindset. Apparently, in the frame of this manipulation procedure, the choice of task characteristics, more specifically stimulus color choice, induced the same implemental mindset with strong action shielding. Personal choice was thus able to protect participants against music effects during the action execution—as suggested by Heckhausen and Gollwitzer (1987).

Although the music manipulation had the expected effect on cardiovascular reactivity in the Assigned Task condition, which replicates previous studies that manipulated mood in cognitive tasks (e.g., Gendolla et al., 2001; Gendolla and Krüsken, 2001b, 2002a, b), participants' mood ratings were not significantly affected by the background music—but the mood change scores at least corresponded to the music valence. Given that the music manipulation had significant effects on mood manipulation checks in previous research (e.g., Gendolla et al., 2021, Study 1; Gendolla and Krüsken, 2001a, 2001b; Gendolla et al., 2001), we still think that our Music manipulation was effective. Moreover, not finding effects on manipulation checks in the presence of effects on the dependent measures cannot be taken as evidence for an ineffective manipulation (Sigall and Mills, 1998). Verbal manipulation checks can only be interpreted if they produce significant effects. If they do not, they do *not* provide evidence that a manipulation failed—especially when effects on the dependent variable occur as expected.

Nevertheless, we also consider the possibility that the Music manipulation led to implicit affective influences instead of consciously experienced ones. Research on the Implicit-Affect-Primes-Effort model (Gendolla, 2012) has revealed that implicitly processed affective stimuli (affect primes) have similar effects on effort intensity as consciously experienced affective states, though the underlying mechanisms are different: explicit affect directly influences perceived task demand and thus effort, whereas implicit affect activates ease and difficulty concepts, which in turn influence subjective task demand and thus effort. The effect on effort is, however, the same and there is replicated evidence that implicitly processed sadness primes result in stronger cardiovascular responses in easy and moderately difficult tasks than respective happiness primes (e.g., Gendolla and Silvestrini, 2011; Silvestrini and Gendolla, 2011; Lasauskaite et al., 2014). In conclusion, although our background music aimed at influencing participants' moods, it may have influenced effort implicitly without inducing conscious affective experiences. However, even if this was the case, our findings still provide evidence for shielding effects against external affective stimulation. Conclusive tests of the question whether task choice can indeed immunize against implicit affective influences on volition will be conducted in upcoming research.

Taking a broader perspective, our present findings add to the existing literature on autonomy and choice. Not only do humans prefer autonomy, self-determination, and choice (Leotti and Delgado, 2011; Leotti et al., 2010; Ryan and Deci, 2000), the opportunity to personally choose actions and goals has been associated with faciliating effects on interest and performance (Cerasoli et al., 2016; Patall et al., 2008; Ryan and Deci, 2006) and personal choice of task characterisitics can justify relatively high effort, which is mobilized if necessary (Bouzidi et al., 2022). Multiple studies, both in laboratory and ecological settings, support the positive effect of choice on performance for children and adults (e.g., Cordova and Lepper, 1996; Reber et al., 2018; Rosenzweig et al., 2019; Zuckerman et al., 1978). The present findings provide a strong indication for an additional benefit of choice: personal choice can protect action execution from incidental affective stimulation.

### 4.1. Conclusions and outlook

The present study helps to further align two areas of research that have made equivocal assumptions about the role of affect in action execution. Theorizing and research on volition suggested that goal pursuit is shielded against incidental affective influences (e.g., Gollwitzer, 1990; Heckhausen and Gollwitzer, 1987), while research on affect and self-regulation has predicted and demonstrated systematic affective influences on effort (e.g., Gendolla, 2000; Gendolla and Brinkmann, 2005)—which is a central aspect of volition (Kuhl, 1986). Building on first research evidence for our integrative action shielding model (Gendolla et al., 2021), the present study shows once again that the way people engage in action—by deliberation and choice vs. external assignment—is decisive. Accordingly, external affective stimulation influences effort-related cardiovascular responses, but only if the task and its characteristics are externally assigned. That is, personal choice shields against incidental affective influences on volition. Importantly, the present research shows that not only the (ostensible) choice of the action itself, but also autonomy in the choice of task characteristics (here choice of the stimulus color) leads to shielding against incidental affective influences during volition. Besides other benefits of choice (Leotti et al., 2010) and the evidence for the facilitating effect of choice on interest and performance (see Cerasoli et al., 2016; Patall et al., 2008; Ryan and Deci, 2017; Ryan and Deci, 2006, for overviews), our findings provide evidence for a further benefit of choice: it helps to shield action execution from external affective stimulation.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpsycho.2022.04.010.

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