

ORIGINAL ARTICLE

Task choice shields against incidental affective influences on effort-related cardiovascular response

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Abstract

In an attempt to integrate theorizing on action shielding with affective influences on effort-related cardiovascular response, an experiment with $N = 115$ university students (90% women) tested whether working on a task by personal choice versus external assignment moderates the effect of happy versus sad background music on effort-related cardiovascular response during task performance. We predicted strong action shielding and low receptivity for incidental affective influences when participants could ostensibly choose the task to be performed. Given the difficult nature of the task, we thus expected strong effort-related cardiovascular responses due to high commitment when the task was chosen. By contrast, for assigned-task participants, we expected high receptivity for incidental affective influences and thus predicted strong cardiovascular reactivity when they were exposed to happy music but low responses due to disengagement when they were exposed to sad music. Effects on responses of cardiac pre-ejection period, systolic blood pressure, and heart rate confirmed our effort-related predictions. Apparently, personal choice of a task can immunize individuals against incidental affective influences on resource mobilization.

KEYWORDS

action shielding, affect, cardiovascular response, effort, volition

1 | INTRODUCTION

There is ample evidence that external affective stimulation systematically influences cardiovascular responses during task performance (see Gendolla & Brinkmann, 2005; Gendolla et al., 2012, for reviews). These responses rely on the sympathetic nervous system impact and reflect effort (Obrist, 1981; Wright, 1996)—the mobilization of resources for action execution (Gendolla & Wright, 2009).

In parallel, theorizing on volition—the initiation, maintenance, and protection of goal-directed action (Kuhl, 1986)—has posited that forming goal intentions leads to a (1) strong commitment to perform respective actions, and (2) a general cognitive orientation facilitating effective goal striving (i.e., an implemental mindset; Gollwitzer, 1990; Heckhausen & Gollwitzer, 1987). Importantly, among the different cognitive mechanisms that facilitate the realization of goals, committed goal

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striving is said to be protected against potentially conflicting external influences, including incidental affective stimulation (e.g., Gollwitzer, 1993; Gollwitzer & Bayer, 1999). This postulated action-shielding effect has been empirically supported by using behavioral measures: in the presence of conflicting goals, the commitment to the focal goal inhibits the cognitive accessibility of alternative goals (Shah et al., 2002) and forming specific implementation intentions specifying the when, where, and how of goal striving successfully shields the execution of goal-directed behavior against adverse affective influences (Achtziger et al., 2008). These findings are to be integrated with theorizing and research on affective influences on effort.

1.1 | Affective influences on effort-related cardiovascular response

Many studies on affective influences on effort-related cardiovascular response have been sparked by the Mood-Behavior-Model (MBM; Gendolla, 2000). The MBM posits that mood states influence effort through their informational value for behavior-related judgments. The integration of this informational mood effect with theoretical assumptions about resource mobilization allows for specific and context-dependent predictions about mood effects on effort-related responses in the cardiovascular system. According to the motivational intensity theory (Brehm & Self, 1989), people are governed by a resource conservation principle and thus avoid investing more effort than necessary. When task difficulty is fixed and clear, effort thus rises proportionally with experienced task difficulty as long as success is possible and the required effort is justified. 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. However, when task demand (1) exceeds the person's ability, or (2) the amount of necessary effort is not justified by the importance of task success, individuals should withdraw effort to avoid wasting their resources. These predictions have found strong empirical support regarding cardiovascular measures of effort (see Gendolla et al., 2012, 2019; Richter et al., 2016; Wright & Kirby, 2001, for reviews).

Considering the effect of affective experiences on effort-related cardiovascular response, the MBM posits that when people are taking on a task, their 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 stronger effort-related cardiovascular response. However, given that a sad mood

should increase subjective difficulty, experienced task demand can become excessive in an objectively difficult task. If the subjectively very high necessary effort is then not justified by a high importance of success, people disengage and reduce effort (e.g., Gendolla & Krüsken, 2001a,). Only in the case of high success importance (e.g., caused by strong needs, high performance incentives, or high outcome expectancies), a sad mood results in very high effort (e.g., Gendolla & Krüsken, 2002a; Silvestrini & Gendolla, 2009a, 2009b). In sum, affect can be assumed to moderate the effect of objective task difficulty on effort-related cardiovascular activity adjustments.

1.2 | The role of task choice

Based on the idea that task choice fosters action shielding (Gollwitzer, 1990; Heckhausen & Gollwitzer, 1987), we suggest an integration of the research lines on volition and affective influences on effort-related cardiovascular response, which so far have been studied in isolation from each other. It seems reasonable to assume that task choice should minimize incidental affective influences on effort. Compared with tasks that are externally assigned to a person—the default procedure in psychological experiments and the above-discussed research on the MBM—self-determined choice of such tasks should be associated with a strong commitment (e.g., Brehm, 1956; 1962; Nenkov & Gollwitzer, 2012) and an implemental mindset (Büttner et al., 2014). Consequently, incidental affective influences on acting on one's goal should be minimized. By contrast, externally assigned tasks should be characterized by a lower commitment and a weaker implemental mindset, and thus action shielding should be reduced. Consequently, incidental affective influences on action execution should be stronger in assigned tasks.

First evidence (Gendolla et al., 2021, Study 2) has supported these theoretical predictions in the context of an easy short-term memory task: when the task was assigned, participants mobilized lower effort assessed as cardiac pre-ejection period (PEP) reactivity when exposed to happy music than when exposed to sad music. By contrast, effort in participants who could choose the task was not affected by the type of music and low in general.

The present research tested our action shielding hypothesis in the context of a difficult task: When that task was assigned, we expected strong affective influences on effort, as previously shown in studies on the MBM (see Gendolla et al., 2012; Gendolla & Brinkmann, 2005). More specifically, exposure to sad music should increase subjective difficulty during performance and the already high demand should become excessive. As the importance of success was rather low in our experimental

setting (there was no performance-contingent incentive that could justify the required resources; e.g., Chatelain & Gendolla, 2016; Freydefont & Gendolla, 2012; Silvestrini, 2015), we predicted weak effort-related cardiovascular response due to disengagement from the assigned task. By contrast, subjective difficulty should be relatively high but feasible when the difficult task was assigned and participants were exposed to happy music. Consequently, we expected effort-related cardiovascular response to be comparatively stronger in this condition (e.g., Gendolla & Krüsken, 2001a, 2002b).

Importantly, these affective stimulation effects should be minimized and effort should be high in general when the task was self-chosen. This was predicted as personal task-choice should lead to a heightened commitment to succeed on the task (Nenkov & Gollwitzer, 2012). According to the principles of motivational intensity theory (Brehm & Self, 1989), task choice should thus justify the high effort that is necessary for performing well on an objectively difficult task (Gendolla & Richter, 2010). Given that task choice should minimize incidental affect's impact on effort, the sad music was *not* expected to result in a different level of effort than the happy music.

1.3 | Effort-related cardiovascular response

Based on Wright's (1996) integration of motivational intensity theory (Brehm & Self, 1989) with considerations about psychophysiological responses in active coping situations (Obrist, 1981), effort intensity can be operationalized by indicators of beta-adrenergic sympathetic impact on the heart. 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 both the independent impacts of sympathetic and parasympathetic activity, heart rate (HR) is not an ideal indicator of effort. By contrast, the heart's contractile force depends on beta adrenergic sympathetic impact (Richter et al., 2016). 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 index of effort (Kelsey, 2012). Stronger beta-adrenergic sympathetic impact does result 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, 2019; Richter

et al., 2016, for reviews). However, next to cardiac contractility, SBP is also influenced by peripheral resistance in the vasculature, 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 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

An experiment tested our conceptual hypothesis that affective influences on effort-related cardiovascular response should be relatively strong in assigned tasks, but weak due to stronger action shielding when tasks are self-chosen. To induce deliberation and subsequent task choice, half the participants could allegedly choose between two tasks, whereas the other half performed an assigned task chosen by their yoked participant in the self-chosen task condition. In fact, all participants worked on the same difficult cognitive task, in which they were continuously presented with different assemblies of letters consisting of vowels and consonants and were asked to correctly memorize the frequency of appearance of the following five vowels (A, E, I, O, U). This required participants to continuously pay attention and to memorize an elevating number of stimuli. During task performance, half of the participants were exposed to happy music, while the other half was exposed to sad music—the incidental external affective stimulation. We expected the music to influence effort-related cardiovascular reactivity, especially PEP, only in the assigned task condition. Given that the cognitive task was difficult, we predicted stronger responses in the happy music (high but feasible subjective task demand) than in the sad music condition (disengagement due to excessive subjective demand; e.g., Gendolla & Krüsken, 2001a, 2002b). By contrast, participants in the chosen task condition should be highly committed and thus be shielded against the music's influence on effort. Consequently, according to the principles of motivational intensity theory (Brehm & Self, 1989), we expected task choice to result in strong effort-related cardiovascular reactivity in the difficult task at hand, independently of the presented music. Altogether, this led to the prediction of a 3:1 pattern of cardiovascular reactivity (especially PEP), with weaker responses in the assigned task/sad music condition than in the other three conditions.

2 | METHOD

2.1 | Participants and design

Previous research applying the present task choice and music manipulations has found significant effects of medium size on resource mobilization measures with samples of 20–22 participants per condition (Gendolla et al., 2021). To have at least the same sample size, we aimed at collecting data of 30 participants per condition to compensate for eventual data loss due to technical problems. In total, 123 undergraduate psychology students were randomly assigned to our 2 (Task: Chosen vs. Assigned) \times 2 (Music: Happy vs. Sad) between-participants experimental design. Physiological data of 3 participants could not be collected because of technical issues at the beginning of the testing; the data collection of additional 2 participants was interrupted by electrode detachment during the baseline or task phases; and the data of additional 3 participants could not be analyzed due to bad signal quality of their impedance cardiograms. Thus, in total, 8 data sets had to be removed from the analyses.

The final sample consisted of $N = 115$ participants (104 women, 11 men; average age 21 years)¹ with the following cell numbers of participants: Chosen Task/Happy Music (28 participants), Chosen Task/Sad Music (31 participants), Assigned Task/Happy Music (27 participants), Assigned Task/Sad Music (29 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 \times 2 factorial design.

2.2 | Physiological measures

A Cardioscreen 1000 system (medis; Imenau, Germany) was used to noninvasively record electrocardiogram (ECG) and thoracic impedance signals (ICG) at a sampling rate of 1000 Hz, from which we derived cardiac PEP (in ms) and HR (beats/min). Two pairs of single-use electrodes (Ag/AgCl; medis, Imenau, Germany) were attached to the left side of the participants' neck and chest (left middle axillary line at the height of the xiphoid). We used BlueBox 2.V1.22 software (Richter, 2010) for

¹The gender distributions were balanced in all four conditions: Chosen Task/Happy Music (25 women/3 men), Chosen Task/Sad Music (28 women/3 men), Assigned Task/Happy Music (25 women, 2 men), and Assigned Task/Sad Music (26 women/3 men). Not surprisingly, a chi-square of these frequency distributions was nowhere near significance ($p = .959$).

data processing (low-pass filtered at 50 Hz). R-peaks were automatically identified using a threshold peak detection algorithm and visually confirmed, allowing to determine HR. The first derivative of the change in thoracic impedance was calculated, and the resulting dZ/dt signal 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), allowing 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 File S1.

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 to the students as a 30-min study on cardiovascular reactivity during a 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 asked to provide written informed consent. The experimenter attached the physiological sensors, started the experimental software, and then 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 scores. Ratings were made using a slider. Its default position was fixed at the middle of the scale and could be pushed toward the extremes by pressing the left and right arrow keys on the keyboard. To prevent suspicion, these affect ratings were introduced as standard measures to account for potentially different feeling states of participants entering the laboratory. Next, cardiovascular baseline scores were assessed during the presentation of a

hedonically neutral 8-min long documentary film about Portugal.

After the 8-min habituation period, participants in the Chosen Task condition were informed that they could now choose one of two tasks based on their preferences. To give participants a reason for their choice, and making the choice relevant, they read: “Current research results show that the possibility of choosing a task has a positive effect on task performance”. After participants had pressed “enter” to continue, brief descriptions of both types of tasks were provided on the next screen: *Memory Task* (“during a memory task, you have to remember the presented stimuli”) versus *Attention Task* (“during an attention task, you have to pay attention to the presented stimuli”). The next screen asked participants to deliberate for 1-min on the question “Do you want to work on a memory task or an attention task?” Participants started that time period with pressing “enter”. After 1 min, participants were asked to indicate their choice by pressing either a prepared green key for the memory task or a red key for the attention task. Next, they were asked whether they would be confident about their decision to assure their commitment. If they pressed the green key for “yes”, the procedure continued; if they pressed the red key for “no”, they had to indicate their choice again and the procedure continued after entering and confirming their decision.

In fact, all participants later worked on the very same task that entailed both types of cognitive processing—memory and attention. In the Assigned Task condition, participants worked on the task chosen by their yoked participant in the task-choice condition. If she or he previously chose the *Memory Task*, participants read “Current research results show a positive effect on task performance when the cognitive task is a memory task”. When the yoked participant previously chose the *Attention Task*, the message was “Current research results show a positive effect on task performance when the cognitive task is an attention task”. That is, as in the Chosen Task condition, there always was a positive performance framing. To create further similarities to the Chosen Task condition, Assigned Task 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 extent could you decide what kind of task to perform?”. Answers were given with a slider on a continuous scale ranging from 1 (*not at all*) to 100 (*very much*).

The task instructions, which were identical for all participants, were headed *Memory Task* or *Attention Task*, respectively. All participants worked on the very same cognitive task requiring both continued attention and memorizing; they were presented with 39 different 4-letter assemblies consisting of only consonants (“NDLV”,

“TSHD”) or consonants and vowels (“APTI”, “BRUR”). In total, the assemblies of letters contained 19 vowels ($3 \times A$; $6 \times I$; $4 \times E$; $2 \times O$; $4 \times U$). Each trial started with a fixation cross (750 ms), followed by an assembly of 4 letters (4 s) and an inter-trial interval that randomly varied between 2 and 4 s. During task performance, participants were presented with a randomized order of the assemblies of letters while cardiovascular activity was assessed. The participants were instructed to count the exact number of the appearing vowels during the entire task lasting 5 min, and to write down the number of vowel presentations for the vowels A, E, I, O, and U at the end of the task. Therefore, the experimenter entered the laboratory once the 5 min were over and provided the participants with a response sheet and a pen.

Before the main task, all participants performed 5 practice trials (LPCW – MULP – LRPQ – LZIC – LPVM) to familiarize themselves with the task. The correct number of presented vowels ($U = 1$, $I = 1$, $A = 0$, $E = 0$, $O = 0$) was presented at the end of the practice trials, 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 several previous studies (e.g., Gendolla et al., 2001, 2021; Gendolla & 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 extent did you find the task difficult?”), reaching from 1 (*not at all*) to 100 (*very difficult*). Next, participants rated the same 4 affect 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 opportunity 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

The 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:4c2xzq5agvds3k4qjnc>

	Chosen task		Assigned task	
	Happy music	Sad music	Happy music	Sad music
PEP	98.48 (2.03)	101.66 (1.84)	101.70 (1.97)	97.86 (1.60)
SBP	104.08 (1.93)	105.74 (1.98)	107.95 (1.89)	107.69 (1.92)
DBP	62.36 (2.42)	59.75 (1.18)	60.37 (1.49)	60.76 (1.10)
HR	82.90 (2.17)	81.92 (2.29)	79.05 (2.21)	79.46 (2.06)

Note: $N = 115$ for all measures.

Abbreviations: DBP, diastolic blood pressure (in mm Hg); HR, heart rate (in beats/min); PEP, pre-ejection period (in ms); SBP, systolic blood pressure (in mm Hg).

ecj57y. Our theory-based predictions about task choice and music effects on effort-related cardiovascular responses were tested with planned a priori contrast analyses, which are the most powerful and thus appropriate statistical tool to test predictions about predicted patterns of means (Rosenthal & Rosnew, 1985; Wilkinson & The Task Force on Statistical Inference of APA, 1999). As explained above, we expected a 3:1 interaction pattern with relatively weak cardiovascular responses (especially PEP) in the Assigned Task/Sad Music condition (contrast weight -3) and stronger responses in the other three conditions (contrast weights $+1$). Variables for which we did not specify theory-based predictions were analyzed with conventional exploratory 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 scores generally become stable toward the end of habituation periods. The cardiovascular measures showed high internal consistency during the last 3 min (Cronbach's $\alpha \geq .96$). Cell means and standard errors of the baseline scores appear in Table 1. Preliminary 2 (Choice) \times 2 (Music) ANOVAs revealed no significant differences between the later conditions ($ps \geq .074$).²

3.2 | Cardiovascular reactivity

To obtain reactivity scores (Llabre et al., 1991), we subtracted the baseline scores from the five 1-min scores of PEP, HR, SBP, and DBP that were assessed during task performance. The constituted scores showed high

²The 3:1 contrast that tested our predictions about cardiovascular reactivity was not significant for any of the cardiovascular baseline values ($p \geq .202$). For readers interested in gender differences in cardiovascular activity, we compared the baseline values of women and men with t -tests. These analyses did not reveal any significant gender differences for baseline values (other $ps \geq .195$).

TABLE 1 Means and standard errors (in parentheses) of the cardiovascular baseline values

internal consistency (Cronbach's $\alpha \geq .91$). Preliminary analyses of covariance (ANCOVAs) of the averaged cardiovascular reactivity scores with the respective baseline scores found no significant associations between baseline and reactivity scores for any of the cardiovascular indices ($ps \geq .083$).

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, $F(1, 111) = 6.00$, $p = .016$, $\eta^2 = 0.05$. As depicted in Figure 1 (top panel), the PEP responses showed the predicted 3:1 pattern (decreases in PEP are reflecting increases in effort intensity).

Additional one-tailed cell contrasts³ revealed that PEP reactivity in the Assigned Task/Sad Music condition ($M = -1.77$, $SE = 0.62$) was significantly weaker than in the Chosen Task/Happy Music ($M = -3.84$, $SE = 0.66$), the Chosen Task/Sad Music ($M = -3.60$, $SE = 0.55$) and the Assigned Task/Happy Music condition ($M = -3.49$, $SE = 0.82$) cells, $ts(111) \geq 1.69$, $ps \leq .049$, $\eta^2s > 0.03$, which in turn did not significantly differ from each other ($ps \geq .739$). This fully confirms our predictions.

3.2.2 | HR reactivity

The 3:1 a priori contrast was also significant for HR, $F(1, 111) = 5.48$, $p = .021$, $\eta^2 = 0.05$, and further supported our effort-related predictions. Cell means and standard errors are displayed in Figure 1 (middle panel).

According to additional one-tailed cell contrasts, HR reactivity in the Assigned Task/Sad Music condition ($M = 3.23$, $SE = 0.74$) was significantly weaker than in the Chosen Task/Happy Music ($M = 5.89$, $SE = 1.08$), the Chosen Task/Sad Music ($M = 5.95$, $SE = 1.00$) and the Assigned Task/Happy Music condition ($M = 5.98$,

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

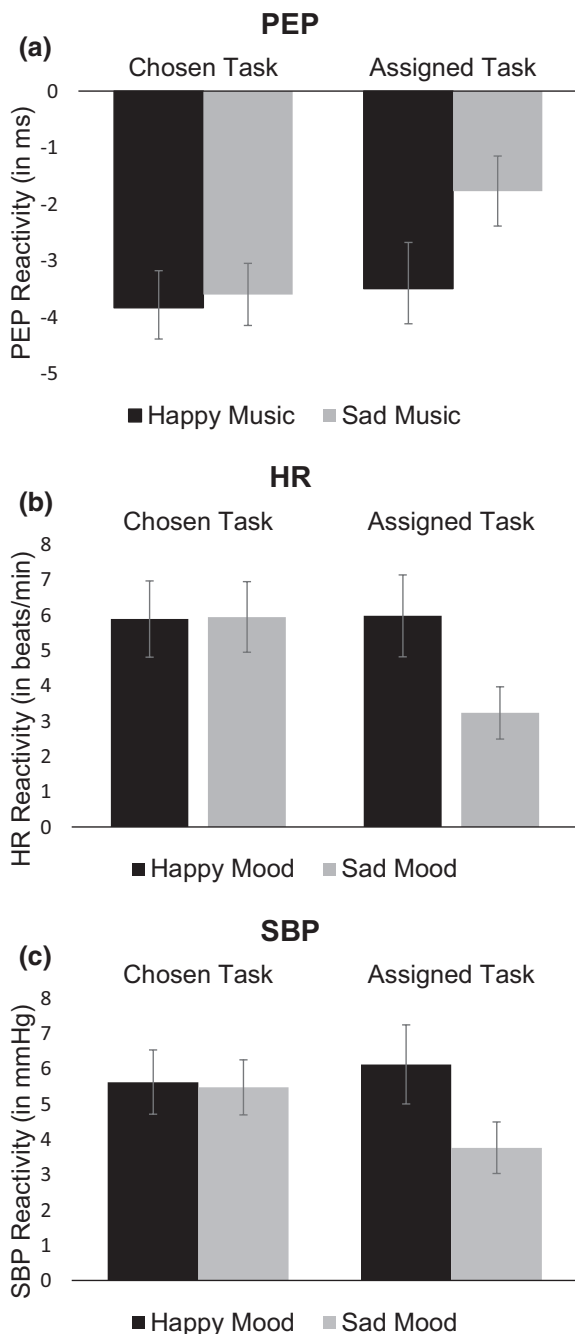


FIGURE 1 Cell means and ± 1 standard errors underlying the combined effect of task choice and music on cardiac pre-ejection period (PEP) reactivity (top panel), heart rate (HR) reactivity (middle panel), and systolic blood pressure (SBP) reactivity (bottom panel) during task performance

$SE = 1.16$), $ts(111) \geq 2.02$, $ps \leq .048$, $\eta^2s > 0.04$, which did not significantly differ from each other ($ps \geq .95$).

3.2.3 | SBP reactivity

Our a priori contrast for SBP was also significant, $F(1, 111) = 4.00$, $p = .048$, $\eta^2 = 0.03$, and further supported

our effort-related hypotheses (see Figure 1, bottom panel). Additional one-tailed cell contrasts revealed that SBP reactivity in the Assigned Task/Sad Music condition ($M = 3.76$, $SE = 0.73$) was significantly weaker than in the Chosen Task/Happy Music ($M = 5.62$, $SE = 0.91$), the Chosen Task/Sad Music ($M = 5.47$, $SE = 0.78$), and the Assigned Task/Happy Music condition ($M = 6.12$, $SE = 1.02$), $ts(111) \geq 1.60$, $ps \leq .05$, $\eta^2s > 0.02$, which in turn did not significantly differ from each other ($ps \geq .610$).

3.2.4 | DBP reactivity

The a priori contrast for DBP was not significant, $F(1, 111) = 1.55$, $p = .216$, although the reactivity pattern corresponded to the 3:1 pattern: Assigned Task/Sad Music ($M = 2.62$, $SE = 0.59$), Chosen Task/Happy Music ($M = 3.15$, $SE = 0.64$), Chosen Task/Sad Music ($M = 3.51$, $SE = 0.57$), and Assigned Task/Happy Music ($M = 4.16$, $SE = 0.93$).

3.3 | Task performance

A 2 (Choice) \times 2 (Music) ANOVA of the percentage of correctly remembered vowel presentations revealed no significant effects ($p > .366$). On average, participants correctly remembered 52% ($SE = 3.02$) of the vowels. This rather low score supports our assumption that the task was difficult. Moreover, memory performance was significantly correlated with the reactivity scores of PEP ($r = -.19$, $p = .043$), SBP ($r = .24$, $p = .01$), HR ($r = .31$, $p = .001$), suggesting that more exerted effort was linked to heightened performance.

3.4 | Verbal measures

3.4.1 | Choice

A 2 (Choice) \times 2 (Music) ANOVA of the choice manipulation check revealed a highly significant Choice main effect, $F(1, 111) = 46.49$, $p < .001$, $\eta^2 = .295$. Participants in the Chosen Task condition ($M = 64.65$, $SE = 3.25$) rated their freedom of choosing the task type as significantly higher than those in the Assigned Task condition ($M = 30.80$, $SE = 3.71$). Other effects were not significant ($ps > .618$).

3.4.2 | Mood

The two positive and negative affect ratings were highly correlated for the pre-task ($rs \geq .74$, $ps < .001$) and

post-task measures ($r \geq .72$, $ps < .001$). We created pre-task affect scores (Cronbach's $\alpha = .85$) and post-task affect scores (Cronbach's $\alpha = .82$) by summing the happiness and the reverse coded sadness ratings at both times of measurement. A 2 (Choice) \times 2 (Music) \times 2 (Time) mixed-model ANOVA only revealed a Time main effect, $F(1, 111) = 6.85$, $p = .01$, $\eta^2 = .058$, reflecting more positive affect scores before ($M = 270.76$, $SE = 6.60$) than after performing the task ($M = 260.88$, $SE = 6.16$), (other $ps > .820$).

3.4.3 | Difficulty

A 2 (Choice) \times 2 (Music) ANOVA of the subjective difficulty ratings revealed no significant effects ($p > .304$). Generally, the difficulty ratings ($M = 58.00$, $SE = 2.01$) were significantly higher than the scale's midpoint (50.00) according to a one-sample t -test, $t(114) = 3.97$, $p < .001$, $\eta^2 = .123$. Apparently, participants saw the task as relatively difficult.

4 | DISCUSSION

The present study supports our action shielding hypothesis and extends first evidence (Gendolla et al., 2021) that task choice shields against incidental affective influences on effort-related cardiovascular responses in the yet unexplored context of a difficult task. Consistent with previous findings on mood effects on effort during the performance of assigned difficult tasks (e.g., Gendolla & Krüsken, 2001a, 2002b), participants in the present assigned task condition showed significantly stronger cardiovascular reactivity when they were exposed to happy background music than those who were exposed to sad music. We had expected this because our task required continuous memorization and attention and was thus experienced as difficult—as indicated by both the performance data and the verbal difficulty manipulation check. In this challenging task context, we expected the happy music to result in subjectively high but feasible task demand during performance and thus strong effort-related cardiovascular response. By contrast, the sad music should add difficulty to the already high objective task demand, resulting in low effort due to disengagement.

Our results clearly confirmed these predictions for our almost entirely female sample. They also replicate previous studies on affective influences on effort-related cardiovascular response in assigned tasks (see overviews by Gendolla & Brinkmann, 2005; Gendolla et al., 2012). Importantly, when participants were induced to deliberate and subsequently choose their task, effort-related

cardiovascular response was strong in general and showed no evidence of music influences. We had predicted this finding because task choice is known to lead to heightened commitment (Nenkov & Gollwitzer, 2012), an action-oriented task-focus (Kuhl, 1986), and an implemental mindset (Gollwitzer, 1990). This should (1) shield against incidental affective stimulation (Gendolla et al., 2021), and (2) justify the high effort that was necessary for the objectively difficult task (Brehm & Self, 1989).

On the physiological level, the predicted reactivity pattern was most pronounced for PEP reactivity—our main effort-related measure. This was expected because PEP is the most sensitive measure of beta-adrenergic sympathetic impact on the heart and thus effort (Kelsey, 2012; Wright, 1996). Corresponding effects occurred on SBP and HR, which is not surprising, because cardiac contractile force systematically influences SBP via its impact on cardiac output. Therefore, many studies have operationalized effort in terms of SBP reactivity (for overviews see Gendolla et al., 2012, 2019; Richter et al., 2016; Wright & Kirby, 2001). However, SBP and to a higher extent diastolic blood pressure (DBP), are also influenced by peripheral vascular resistance, making SBP responses a noisier effort index than PEP and effort effects on DBP unlikely. Nevertheless, the present SBP effects are no surprise. The same holds true for the corresponding effects on HR, which have also been observed before (e.g., Brinkmann & Gendolla, 2007; Eubanks et al., 2002; Zafeiriou & Gendolla, 2017). The a priori contrast effects on PEP, SBP, and HR were of medium size and our sample was big enough to detect significant effects of that size according to our sensitivity analysis.

In contrast to the cardiovascular measures, no significant manipulation effects emerged on task performance. This might be due to the nature of our 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 task only allowed to calculate the percentage of correct responses after the task. However, it had the advantage to require continuous engagement over the entire performance period. The non-significance of the performance pattern might also be due to the complexity of the effort-performance link, that renders the link between effort and performance difficult to predict: 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 strategic skills (Locke & Latham, 1990). Consequently, one cannot expect that variations in effort intensity are always reflected in the level of performance. Nevertheless, the significant correlations between cardiovascular responses and memory performance suggest that there was at least

some link between effort and performance in this study. Moreover, participants' overall rather poor performance supports our assumption that we successfully created an objectively difficult task. This was further supported by our self-report measure of task difficulty.

Also, our task choice manipulation had a significant effect on participants' feelings of having control over the type of task they worked on. Furthermore, not a single participant verbally doubted our choice manipulation during the debriefing at the end of the testing procedure. That is, even if participants could not really determine the type of task they worked on in the chosen task condition, our choice manipulation worked as intended—which is also suggested by its predicted effect on effort-related cardiovascular reactivity.

However, although the music manipulation had the expected effect on cardiovascular reactivity in the assigned task condition, which replicates previous studies that manipulated mood in difficult tasks (e.g., Gendolla & Krüsken, 2001a, 2002a, 2002b), participants' mood ratings were not significantly affected by the background music. Given that the music manipulation had significant effects on mood manipulation checks in several previous studies (Gendolla et al., 2001, 2021; Gendolla & Krüsken, 2001a, 2001b), we do not doubt that our music manipulation was effective. But in contrast to those previous studies, we used slider scales instead of 7-point rating scales to assess participants' mood. Thus, we cannot rule out the possibility that the slider measure was simply not as reliable as the previously used scales. However, 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 & Mills, 1998). Self-report manipulation checks can only be interpreted if they produce significant effects. If they do not, they do *not* provide evidence that a manipulation has failed. Nonetheless, we acknowledge the importance of replicating the present findings with significant effects on mood manipulation checks. Likewise, the present study calls for replication with a more balanced distribution of women and men—though we do not see any reason why the present effects should be restricted to women only.

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-related cardiovascular response as consciously experienced affective states, though the underlying mechanisms are different: explicit affect directly influences perceived task demand and thus effort (e.g., Gendolla & Krüsken, 2002c), whereas implicit affect activates ease and difficulty related concepts (e.g.,

Lasauskaite et al., 2017), 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 happiness primes result in stronger cardiovascular responses in objectively difficult tasks than respective sadness primes (e.g., Framorando & Gendolla, 2019; Lasauskaite et al., 2014; Silvestrini & Gendolla, 2011). Thus, although our background music aimed at influencing participants' conscious 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 of whether task choice can indeed immunize against implicit affective influences on volition will need to be conducted in future research.

Finally, one might wonder if the observed music effects on cardiovascular response may have been caused by differences in music induced arousal rather than the music valence. However, if that were the case, one might expect a music main effect on cardiovascular activity—which was not observed. Moreover, previous studies also assessed electrodermal responses to the music presentations and did not find any music effects on that arousal measure either (Gendolla et al., 2001; Gendolla & Krüsken, 2001a). Finally, it is of note that the same music had opposite effects on cardiovascular response during an easy task (Gendolla et al., 2021, Study 2; see also Gendolla & Krüsken, 2001a). How could such opposite effects be caused by the same music if it works via arousal? Considering these points, we do not see how potential music effects on arousal could explain our findings.

4.1 | Conclusions and outlook

The present study helps to integrate 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 & Gollwitzer, 1987), while research on affect and self-regulation has predicted and demonstrated systemic affective influences on effort (e.g., Gendolla, 2000; Gendolla & Brinkmann, 2005)—which is a central aspect of volition (Kuhl, 1986). The present study demonstrates that the way people engage in action—by deliberated choice versus external task assignment—is decisive. Accordingly, external affective stimulation influences effort-related cardiovascular response, but only if a task is externally assigned; personal task choice shields against incidental affective influences on volition. Besides other benefits of choice (see Leotti et al., 2017) and the evidence for the facilitating effects

of choice on interest and performance (see Cerasoli et al., 2016; Patall et al., 2008; Ryan & Deci, 2006, 2017), our findings suggest that choice helps to shield action execution from external affective stimulation. Together with the first research evidence showing that task choice leads to immunization against incidental affective influences when task demand is objectively low (Gendolla et al., 2021), the present study provides further evidence for a possible alignment between affect and volition in the context of objectively difficult tasks.

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AUTHOR CONTRIBUTIONS

Johanna R. Falk: Conceptualization; data curation; formal analysis; investigation; methodology; writing – original draft. **Peter M. Gollwitzer:** Conceptualization; investigation; validation; writing – review and editing. **Gabriele Oettingen:** Conceptualization; investigation; validation; writing – review and editing. **Guido H. E. Gendolla:** Conceptualization; data curation; formal analysis; funding acquisition; methodology; project administration; resources; supervision; writing – review and editing.

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