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Choosing Task Characteristics Oneself Justifies Effort:

A Study on Cardiac Response and the Critical Role of Task Difficulty

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Abstract

This experiment investigated how the personal choice of task characteristics influences resource mobilization assessed as effort-related cardiac response during a task of clearly low vs. unclear (but also low) difficulty. We expected that the personal choice of the color of memory task stimuli would justify higher effort during task performance than external color assignment. Applying the logic of motivational intensity theory (MIT; Brehm et al., 1983; Brehm & Self, 1989), we further predicted that the personal choice of the stimuli's color would directly lead to higher effort intensity than external color assignment when task difficulty was unclear but not when the task difficulty was clear. When task difficulty was low and clear, we expected actual effort to be low in general, because high resources are not necessary for a clearly easy task. Results were as expected: when task difficulty was unclear, participants who had personally chosen the stimuli's color showed significantly stronger cardiac pre-ejection period reactivity, reflecting higher effort, than those in the other three conditions. These findings provide first evidence that personal choice justifies relatively high effort and further support the principles of MIT regarding the critical role of task difficulty for resource mobilization.

Keywords: Choice, Deliberation, Effort, Cardiovascular Response

Introduction

Choice has many beneficial effects on individuals' motivation and action (see Leotti et al., 2010; Patall et al., 2008, for reviews). To name only a few examples, giving individuals the opportunity to personally choose what they prefer to do or how they want to execute their actions can enhance intrinsic motivation and interest (Reber et al., 2018; Rosenzweig et al., 2019; Ryan & Deci, 2000; Zuckerman et al., 1978), facilitate learning (Cordova & Lepper, 1996; D'Ailly, 2004; Schneider et al., 2018), and increase cognitive performance (Legault & Inzlicht, 2013). Choice is posited to have these effects because it gives individuals control over themselves and their environment (Leotti & Delgado, 2011) and because it can contribute to the satisfaction of a basic human need—the need for autonomy (see Deci & Ryan, 2008). Or, as stated by Ryan and Deci (2017, p.10): "When acting with autonomy, behaviors are engaged wholeheartedly".

In parallel, volition theories have postulated that deliberation and personal action choice fosters goal striving and action control, because intention formation builds up commitment (Ach, 1935; Gollwitzer, 1990; Heckhausen & Gollwitzer, 1987; Kuhl, 1986; Lewin, 1926; see also Klinger, 1975), which is defined as the willingness to attain a goal (Locke et al., 1988). Once individuals decide to pursue a certain goal—or choose between goal-relevant characteristics (e.g., Gollwitzer et al., 1990)—they commit themselves (consciously or unconsciously), strive to achieve it, and benefit from an implemental mindset (Gollwitzer, 1993; Nenkov & Gollwitzer, 2012). People become task-focused (Kuhl, 1986) and shielded against external affective influences (e.g., Achtziger et al., 2008; Falk et al., 2022; Gendolla et al., 2021) or temptations (e.g., Shah et al., 2002) that could impede goal attainment. All that in service of being committed to their decision.

Making a choice means the resolution of an internal conflict. Choice has been shown to increase commitment to one's decision (Brehm, 1956, 1962) and to create the tendency to enact it (Harmon-Jones et al., 2015). Referring to effort—i.e. the mobilization of resources to carry out instrumental behavior (Gendolla & Wright, 2009)—individuals who have the freedom to make behavioral choices should thus be willing to invest high resources for attaining their goals. Nonetheless, it is still unclear if action-related choice only *justifies*[1] effort—i.e. determines the magnitude of maximally justified effort for action execution—or whether it directly leads to the *mobilization* of resources. We think the well-supported principles of motivational intensity theory can provide an answer.

Choice and Effort

Motivational intensity theory (MIT; Brehm et al., 1983; Brehm & Self, 1989) builds on the resource conservation principle (Ach, 1935; Gibson, 1900; Tolman, 1932). Accordingly, people avoid *wasting* effort (rather than avoiding effort itself) and thus try to do no more than necessary for attaining their goals. Basically, MIT posits that effort depends on two factors, namely task difficulty and success importance. The latter factor refers to the importance of successfully executing a specific goal-directed action, and therefore determines the level of *potential motivation*—the magnitude of effort that is maximally *justified* for a given task (see Wright, 2008). We posit that personal choice influences the level of potential motivation in that self-chosen actions justify higher effort than assigned actions.

In MIT, the clarity of task difficulty plays an important role in resource mobilization. When task difficulty is clear, effort should proportionally rise with it as long as success is possible and the necessary effort is justified by the importance of success. If the necessary effort exceeds what is justified or if difficulty is too high for succeeding, individuals should disengage to prevent wasting resources (see Gendolla et al., 2012, 2019; Richter et al., 2016;

Wright & Kirby, 2001, for reviews). However, when task difficulty is unclear, individuals cannot rely on it to estimate the amount of necessary effort. Therefore, under this specific condition, effort should directly depend on success importance. Supporting this idea, numerous studies have shown that certain factors—such as incentive value (Richter & Gendolla, 2006, 2007, 2009) or motives (Mazeres et al., 2019, 2021; Richter et al., 2021)—can determine success importance and thus directly influence effort under the condition that task difficulty is unclear. Only individuals suffering from depressive symptoms did not show this direct effect of success importance on effort intensity (e.g., Brinkmann et al., 2009; Brinkmann & Franzen, 2013; Franzen & Brinkmann, 2015, 2016).

In Study 1 by Richter and Gendolla (2006) for instance, participants performed an actually easy memory task. The low difficulty of the task was clear for half of the participants, but unclear for the other half. In addition, participants were promised an attractive vs. rather unattractive reward for success, which should determine the importance of success. Following the MIT-based predictions, participants in the unclear difficulty condition invested more effort (assessed physiologically), when the expected reward was attractive than when it was unattractive. Here, effort was directly determined by the importance of success. In the clearly easy condition, however, participants invested low effort independently of the nature of the reward. Here, effort was directly determined by task difficulty—which was low and only required the mobilization of low resources regardless of the incentive value. That is, even if all participants actually performed the same easy task, effort was determined by different variables: when task difficulty was clear, effort depended on it. But when difficulty was unclear, effort was a direct function of success importance. In the present study we expected a corresponding effect for the role of personal choice.

As discussed above, choice (Brehm, 1956, 1962) and intention formation (Nenkov & Gollwitzer, 2012) increase individuals' commitment—their willingness to reach a goal (Locke et al., 1988). Thus, in terms of the MIT, succeeding on a task with self-chosen characteristics should be more important than succeeding on a task with assigned characteristics. Consequently, effort should be determined by the opportunity to choose when task difficulty is unclear, but it should depend on task difficulty if the latter is clear. The present experiment tested this idea.

Effort-Related Cardiac Response

To assess effort objectively, we relied on Wright's (1996) integration of MIT with Obrist's (1976, 1981) psychophysiological active coping approach. Accordingly, assessing β-adrenergic sympathetic nervous system impact on the heart provides a sensitive measure of effort intensity and a compelling number of studies support this approach (see Gendolla et al., 2019; Richter et al., 2016 for reviews). Noninvasively, β-adrenergic sympathetic nervous system impact is mirrored by cardiac pre-ejection period (PEP)—a measure of cardiac contractile force. It reflects the time interval (in ms) between the beginning of the muscle depolarization in the heart’s left ventricular and the opening of the aortic valve (Berntson et al., 2004). PEP becomes shorter—reflecting increased effort—as the heart’s contractile force increases (see Kelsey, 2012; Richter et al., 2008). To assess possible preload (ventricular filling) and afterload (arterial pressure) effects on PEP (Sherwood et al., 1990), it should, however, always be measured together with heart rate (HR) and blood pressure.

The Present Experiment

We tested whether letting participants choose characteristics of an upcoming task vs. assigning those characteristics to them would influence their effort intensity according to the principles of MIT. Participants in the Chosen Color condition could choose the color of the task stimuli. Participants in the Assigned Color condition could not choose that color themselves. That is, in terms of the mindset theory of action phases (Heckhausen &

Gollwitzer, 1986), participants in the Chosen Color condition deliberated about aspects of an upcoming action (deliberative mindset), crossed the Rubicon, and entered into the action phase (implemental mindset). By contrast, participants in the Assigned Color condition started the task without that. They received the stimuli in the color that had been previously chosen by their yoked participant in the Chosen Color condition. All participants worked on the same objectively easy computerized memory task. However, the low difficulty level was clear for only half of them—those participants were informed about the upcoming low workload and the duration of the task. Participants in the Unclear Difficulty condition did not receive any difficulty-related information.

We hypothesized that personal choice of the task stimuli's color would justify higher effort than being assigned to it. According to the logic of MIT (Brehm & Self, 1989), we expected this to result in relatively high effort in the Chosen Color/Unclear Difficulty condition but low effort in the other three conditions, resulting in a 3:1 pattern of effort-related cardiac response during performance. As outlined above, this should happen because personal choice of the task stimuli's color should justify higher effort than external color assignment. The higher *justified* resources should, however, only be *mobilized* if task difficulty was unclear. When it was clear that the task was easy, only low effort should be necessary and was thus predicted in compliance with the resource conservation principle.

Method

Participants and Design

Previous research applying a comparable choice manipulation 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. However, due to the restrictions in the context of the COVID 19 pandemic, we were only able to collect data of 113 instead of the intended 120 undergraduate psychology students. All participants were randomly assigned to our 2 (Choice) x 2 (Difficulty) between-participants experimental design. Due to technical issues, 7 data sets could not be analyzed, leading to a final sample consisting of *N* = 106 participants (88 women, 18 men; average age 21 years) distributed as follows: Chosen Color/Easy (28 participants), Chosen Color/Unclear Difficulty (25 participants), Assigned Color/Easy (24 participants), Assigned Color/Unclear Difficulty (29 participants).[2] 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 x 2 factorial design.

Physiological Measures

A Cardioscreen 2000 system (medis, Imenau, Germany) noninvasively recorded electrocardiogram (ECG) and thoracic impedance (ICG) signals with 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/AgCI; 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 the data processing (low-pass filtered at 50 Hz): R-peaks were automatically identified using a threshold peak detection algorithm and then 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 automatically stored by the monitor.

Readers who are interested in more detailed hemodynamic responses that were unrelated to our hypotheses can find analyses of cardiac output and total peripheral resistance in the Supplementary Online Material.

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 the performance of a cognitive task. A hired experimenter who was unaware of both the hypotheses and experimental conditions conducted all laboratory testing sessions. Upon arrival, participants were welcomed, seated in a comfortable chair in front of a computer, and provided written informed consent. The experimenter attached the physiological sensors, started the experimental software, and went to an adjacent control room.

First, cardiovascular baseline values were assessed during the presentation of a hedonically neutral 8-min long film about trees. Next, the task instructions were displayed. Participants in the Easy condition read: "During 5 minutes, 4 letter series with 4 letters each will appear on the screen. At the beginning of the task, only one letter series will be presented, and each 75 seconds, a new series will be added. Thus, at the end of the 5 minutes, all 4 series will be presented on the screen. Your task is to memorize the 4-letter series and to write them down in their correct order of appearance once the 5 minutes are over".

Participants in the Unclear Difficulty condition were not informed about the number of letter series, the number of letters per series, the presentation timing, or the task duration. They received the following vague instructions: "During the task, multiple letter series will appear on the screen. At the beginning of the task, only one series will be presented, and the other series will be added later on. At the end of the task, all letter series will be present on the screen. Your task is to memorize all letter series and to write them down in their correct order of appearance once the task is over".

Before starting the task, participants in the Chosen Color condition learned that they could now chose one of four colors in which the task stimuli would be displayed, based on their preference. To give participants a reason for their choice, they read: "Current research results show that the possibility of choosing stimuli's color has a positive effect on task performance". After participants had pressed "enter" to continue, examples of the stimuli colors (red, blue, green, yellow) appeared on the next screen. The next screen asked participants to deliberate for 1-min on the question "Which stimulus color do you prefer?" Participants started that period by pressing "enter". After 1-min, they were asked to indicate their choice by pressing a color corresponding key. Next, they were asked whether they would be sure about their decision to assure their commitment. If they pressed a green key for "yes", the procedure continued; if they pressed a red key for "no", they had to indicate their choice again and the procedure continued after entering and confirming their decision. In the Assigned Color condition, the task stimuli's color corresponded to the color chosen by their yoked participant in the Chosen Color condition. For example, if the yoked participant had previously chosen 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 continuing.

Next, 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*). The slider’s default position was fixed mid-scale and could be pushed towards the extremes by pressing the left and right arrow keys on the keyboard. In order to prevent participants in the Unclear Difficulty condition from guessing a difficulty level themselves and thus reducing the unclarity of task difficulty we did not assess subjective difficulty ratings.

Before starting the main task, instructions were once again displayed as a reminder, and participants were informed that the letter series would be presented in the color of their choice (“Based on your choice, the task will be presented in the color blue / yellow / red / green”, respectively) or simply in the assigned color (“The task will be presented in the color blue / yellow / red / green”, respectively).

Then, all participants worked on the same memory task—but as noted above—provided with clear vs. unclear information about the number and appearance mode of the items and the task duration. Participants were presented with 4 different 4-letter series (“ALMP”, “EPQZ”, “TSAM”, “CLTU”). At the beginning, only the first series (“ALMP”) was presented on the screen, and each 75 seconds, a new letter series was added. The position of the letter series on the computer screen was unpredictable (to give an example: the first letter series appeared in the left corner of the screen, the second in the middle of the screen) to prevent participants in the Unclear Difficulty condition to guess, based on the position and size of the letters, how many series would be presented in total.

After the 5 minutes of the task, participants were asked to enter all 4-letter series in their order of appearance using the computer keyboard in front of them. Their responses appeared on the computer screen, and participants were informed about the possibility to modify their response using the "backspace" key. To continue once they had finished typing in all remembered letters, participants were instructed to press "enter". Then, participants answered 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.

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:tn2djwi7xbh2pegaskdnvyilmu. We tested our theory-based predictions about the combined effect of Color Choice and Task Difficulty on effort-related cardiovascular response with *a priori* contrast analysis, which is the most powerful and thus appropriate statistical tool to test predictions about complex interactions and 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 strong cardiovascular responses (especially PEP) in the Chosen Color/Unclear Difficulty condition (contrast weight +3) and weaker reactivity in the other three conditions (contrast weights -1). Variables for which we did not specify theory-based predictions were analyzed with conventional exploratory 2 (Choice) x 2 (Difficulty) ANOVAs.

Cardiovascular Baselines

We had *a priori* decided to constitute cardiovascular baseline activity scores by averaging values assessed in the last 3-min of the habituation period because cardiovascular baseline values generally become stable towards the end of habituation period. The cardiovascular measures showed high internal consistency during the last 3 min (Cronbach's αs ≥ .97). Cell means and standard errors of the baseline scores appear in Table 1. Preliminary 2 (Choice) x 2 (Difficulty) ANOVAs revealed no significant differences between the later conditions (*p*s ≥ .339) [3].

Cardiovascular Reactivity

We created cardiovascular 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. 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, $F(1, 101) = 4.17$, $p = .044$, $\eta^2 = 0.04$. Therefore, we further analyzed baseline-adjusted HR reactivity scores to prevent possible carryover or initial values effect. No significant associations emerged between baseline and reactivity scores of PEP, SBP, and DBP (*ps* ≥ .231).

PEP Reactivity. In line with our hypothesis, the theory-based *a priori* contrast for PEP reactivity—our primary effort-related measure—was significant, $F(1, 102) = 5.56$, $p = .020$, $\eta^2 = 0.05$. As depicted in Figure 1, the PEP responses showed the predicted 3:1 pattern (note that decreases in PEP are reflecting increases in effort intensity). This confirms our predictions.

Additional cell contrasts revealed that PEP reactivity in the Chosen Color/Unclear Difficulty ($M = -4.82$, $SE = 1.03$) was significantly stronger than in the Chosen Color/Easy condition ($M = -2.45$, $SE = 0.68$), $t(102) = 2.17$, $p = .016$, $\eta^2 = 0.04$, and the Assigned Color/Unclear Difficulty condition ($M = -2.26$, $SE = 0.63$), $t(102) = 2.36$, $p = .010$, $\eta^2 = 0.05$.[4] Only the difference between the Chosen Color/Unclear Difficulty and Assigned Color/Easy conditions ($M = -3.31$, $SE = 0.73$) was not significant, $t(102) = 1.33$, $p = .093$, although the reactivity pattern clearly followed our predictions. The Chosen Color/Easy, Assigned Color/Unclear Difficulty, and Assigned Color/Easy conditions did not significantly differ from one another (*p*s $\geq$ .340).

HR and Blood Pressure Reactivity. The *a priori* contrasts for SBP, DBP, and baseline-adjusted HR were not significant, *Fs* $\leq$ 2.46, *ps* $\geq$ .120. Cell means and standard errors appear in Table 2.

Task Performance

On average, participants correctly remembered 13 out of the 16 letters presented in the four series (M = 12.97, SE = 0.51). This high score supports our assumption that we created an easy task. A 2 (Choice) × 2 (Difficulty) ANOVA of the number of correctly remembered letters revealed no Choice or Difficulty main effects (*ps* $\geq$ .536), but a significant Choice x Difficulty interaction effect $F(1, 102) = 7.15$, $p = .009$, $\eta^2 = 0.07$. Cell means and standard errors appear in Table 3. Comparisons with LSD post hoc tests found that participants in the Chosen Color condition correctly recalled significantly more letters in the Unclear Difficulty condition than in the Easy condition ($p = .022$). This corresponded to our effort effect in terms of PEP reactivity. In the Assigned Color condition, the memory performance pattern tended to be inversed, but the difference was not significant ($p = .150$).

A correlation analysis further revealed that PEP reactivity during the task was negatively correlated with the number of correctly remembered letters, $r = -.241$, $p = .013$, indicating a general link between effort and memory performance: participants memory performance increased when their PEP became shorter (reflecting increased effort). None of the other cardiovascular measures was significantly correlated with memory performance (*rs* $\leq$ .051, *ps* $\geq$ .601).

Choice Manipulation Check

A 2 (Choice) x 2 (Difficulty) ANOVA of the verbal color choice manipulation check revealed a highly significant Choice main effect, $F\ (1, 102) = 19.49$, $p < .001$, $\eta^2 = .16$. Participants in the Chosen Color condition ($M = 44.57$, $SE = 3.66$) rated their freedom of choosing the task characteristics as much higher than those in the Assigned Color condition ($M = 22.43$, $SE = 3.26$). Other effects were not significant (ps $\geq .498$).

Discussion

This study supports our hypothesis that the freedom to personally choose task characteristics justifies high effort during task performance. Consistent with our predictions, participants in the Unclear Difficulty condition showed relatively strong effort-related cardiac reactivity during the memory task when they could previously choose their preferred task color themselves compared to those who were assigned to a color. We had predicted this effect because choice is known to lead to high commitment (Nenkov & Gollwitzer, 2012; Ryan & Deci, 2017), an action-oriented task-focus (Kuhl, 1986), and an implemental mindset (Gollwitzer, 1990). We expected personal choice especially to increase commitment (Brehm, 1956, 1962)—the willingness to attain a goal (Locke et al., 1988)—which should render success important. However, as success importance only directly determines resource mobilization when difficulty is unclear (Mazeres et al., 2019, 2021; Richter et al., 2021; Richter & Gendolla, 2006, 2007, 2009), we expected participants in the Chosen Color condition to mobilize higher resources than those in the Assigned Color condition when task difficulty was unclear. This is what we have found for cardiac PEP reactivity—a reliable and valid measure of actual effort intensity (Kelsey, 2012; Wright, 1996). By contrast, when the task was clearly easy, participants in both the Chosen Color and Assigned Color conditions showed only weak PEP reactivity. We had expected this because although choice and intention formation increase individuals' willingness to attain a goal (Locke et al., 1988), people avoid *wasting* resources and try to do no more than necessary for goal attainment (Ach, 1935; Gibson, 1900; Tolman, 1932).

After the many studies that have supported the principles of motivational intensity theory (Brehm & Self, 1989) for settings in which task characteristics were assigned to participants (see Gendolla et al., 2012, 2019; Richter et al., 2016; Wright & Kirby, 2001, for overviews), the present findings show that those principles also apply to settings in which people can choose how they want to execute an action. The opportunity to choose task characteristics justified higher effort than working on a task in which these characteristics were externally assigned—which is the default procedure in psychology experiments. When task difficulty was unclear, this resulted in corresponding effects on actual effort. But when task difficulty was clear, actual effort was a function of it. Consequently, PEP reactivity occurred in the predicted 3:1 pattern.

As a limitation, we acknowledge that the direct follow-up cell comparison between the Chosen Color/Unclear Difficulty and the Assigned Color/Easy conditions fell short of significance, although the PEP responses in the former condition were stronger than in the latter. Weak effects can have various reasons, including chance. However, one may speculate that still clearer task instructions could have led to a stronger difference between the Chosen Color/Unclear Difficulty and the Assigned Color/Easy conditions. Thus, it could be informative to replicate the present study with stronger instructions, including more detailed information about the definition of success criteria and performance measures (e.g., identifying speed of recall as irrelevant). One might also aim for higher commitment and thus still higher success importance in the Choice condition. Therefore, one could replicate the present study with an alternative and potentially more powerful Choice manipulation where participants ostensibly choose between different actions (e.g., attention task vs. memory task;

see Falk et al., 2022; Gendolla et al., 2021) instead of task characteristics. Nonetheless, the significant overall PEP effect clearly supported the predicted pattern and it is of note that apparently arbitrary color choices could evidently justify relatively high effort during task performance.

In a larger perspective, our findings add to previous evidence for the role of self-relevance in effort (Gendolla & Richter, 2010)—i.e. conditions in which task performance is linked to individuals' self-esteem, self-definition, and interests. When the self is involved in an action—which is the case in settings that permit at least some autonomy (Ryan & Deci, 2000)—people are willing to mobilize more effort than under self-irrelevant conditions. Up to the level of maximally justified effort, resource mobilization relies then, however, on task difficulty. This has, for example, been shown for performance conditions with high vs. low implication for persons' self-esteem (e.g., Gendolla & Richter, 2005, 2006). The present study adds the important evidence that personal choice of task characteristics has a corresponding effect.

On the physiological level, the predicted reactivity pattern was significant for PEP reactivity—our main effort-related cardiac parameter—but not for SBP, DBP, and HR reactivity. This is not astonishing, because PEP is the most sensitive index of β-adrenergic activity that can be assessed noninvasively, and thus a less noisy effort measure than SBP, HR, or DBP (Richter et al., 2008). Importantly, there were no decreases in HR or blood pressure during task performance. That is, PEP reactivity can have hardly been affected by cardiac preload or vascular afterload effects instead of β-adrenergic sympathetic activity (Sherwood et al., 1990).

Regarding the validity of our manipulations, participants' general high performance supports our assumption that we successfully created an objectively easy task. According to our verbal choice manipulation check, also our choice manipulation was successful—which is already evident in the support of our predictions regarding PEP reactivity. However, in addition to the expected effect on our main dependent variable, there was also a highly significant color choice effect on participants' reported feeling of having control over the characteristics of the task they worked on. This further indicates a successful choice manipulation. In addition to the verbal check that assessed the feeling of having control before the task, our color choice manipulation also allowed participants to experience the consequence of their choice during task performance: the stimuli appeared in the chosen color. We conclude that our choice and difficulty manipulations were both effective—as already indicated by the evidence for the predicted pattern of PEP reactivity that supported our effort-related predictions.

Although not of central interest and analyzed exploratively, we found a significant Choice x Difficulty interaction effect on participants' memory performance. Participants who could choose their task color correctly recalled significantly more letters in the Unclear Difficulty condition—where they also mobilized higher resources—than in the clearly Easy condition. Participants who were assigned to a color tended to show the opposite pattern: they slightly performed better in the Easy than in the Unclear Difficulty condition, but that difference was not significant. That is, memory performance largely corresponded to the intensity of effort during the task, which was further supported by a significant correlation between PEP reactivity and memory performance. However, although effort and performance showed some correspondence in the present study we should not forget that the link between effort and performance is complex. Effort intensity (behavioral input) and performance (behavioral output) are not conceptually identical and performance depends beside effort also, or even more, on task-related capacity and strategies (Locke et al., 1990). Consequently, one cannot expect that variations in effort intensity are always reflected by effects on performance. Performance provides only a limited indication of resource investment.

However, the significant correlation between PEP reactivity and memory performance suggests that there was at least some link between effort and performance in this study: participants who invested more effort also performed a bit better.

Regarding the effort-performance link in a larger perspective, it is also of note that recent approaches in cognitive neuroscience have defined the effort construct in relation to performance. According to Shenhav et al. (2017, p. 101), for example, "effort refers to the set of intervening processes that determine what level of performance will in fact be realized". However, those approaches focus on effortful cognitive processing, like cognitive control, rather than the process of resource mobilization itself. We do not see it as necessary to include a link to action outcomes in the definition of the intensity of action input. Accordingly, we see effort and performance as independent constructs, which can but do not have to be linked (for more details, see Silvestrini et al., 2021; Silvestrini & Gendolla, 2019). In the tradition of MIT (Brehm & Self, 1989) and its precursors we focus on the process of resource mobilization itself and have operationalized effort accordingly as sympathetic nervous system impact (i.e. the activation system) on the body's resource transport network—the cardiovascular system (Wright, 1996).

Conclusions

This study brought first evidence that personal choice justifies objectively assessed effort, and that it therefore influences goal pursuit by determining persons' willingness to achieve certain goals. This adds to the multiple other demonstrated benefits of behavioral choice on motivation and action (see Leotti et al., 2010; Patall et al., 2008, for reviews): when people have the freedom to choose how they want to execute an action, they are willing to apply themselves. However, the present study also showed that the willingness to mobilize high resources for succeeding on a task after having chosen some of its characteristics does only directly determine effort intensity if task difficult was unclear. When task difficulty was clear, effort was a direct function of it. This brings further support to the principles of MIT (Brehm & Self, 1989)—this time regarding the effects of self-chosen vs. externally assigned task characteristics on effort intensity during task performance. Taken together, by bridging theorizing on self-determination (Ryan & Deci, 2017), volition (Heckhausen & Gollwitzer, 1987), and the psychophysiology of effort (Wright, 1996), our study showed that the choice of task characteristics justifies the mobilization of high resources but that actual effort intensity primarily relies on task difficult—if the difficulty of a task is clear.

Footnotes

[1] It is of note that the definition of *effort justification* used in the MIT context differs from that used by Inzlicht et al. (2018, "effort paradox") or Norton et al. (2012, "Ikea effect"), which refers to the increased value of an object that requires effortful control to be obtained. In terms of MIT, the latter is actually the magnitude of goal valence, which is directly dependent on effort intensity (Brehm et al., 1983; see Wright & Brehm, 1989, for an overview).

[2] The gender distributions were balanced in all four conditions: Chosen Color/Easy (23 women/5 men), Chosen Color/Unclear Difficulty (21 women/4 men), Assigned Color/Easy (19 women, 5 men), and Assigned Color/Unclear Difficulty (25 women/4 men). Not surprisingly, a chi-square of these frequency distributions was nowhere near significance (p = .920).

[3] The 3:1 contrast that tested our predictions about cardiovascular reactivity was not significant for any of the cardiovascular baseline values (ps ≥ .556). 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). These analyses revealed a significant gender difference for baseline values of PEP, $t(104) = 2.59$, $p = .011$, $\eta^2 = 0.06$, due to shorter PEP for women (M = 99.48, SE = 0.93) than for men (M = 105.74, SE = 2.86), and SBP, $t(104) = 3.98$, $p < .001$, $\eta^2 = 0.13$, due to higher SBP for women (M = 113.02, SE = 2.51) than for men (M = 105.11, SE = 0.74). No other cardiovascular measures showed significant gender differences for baseline values (ps ≥ .332). Further, there were no significant gender differences in the cardiovascular response scores (ps ≥ .265).

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

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Table 1

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

	Chosen Color		Assigned Color	
	Easy	Unclear Difficulty	Easy	Unclear Difficulty
PEP	101.62 (2.06)	99.57 (1.85)	101.31 (2.20)	99.72 (1.41)
SBP	106.77 (1.68)	107.29 (1.63)	106.22 (1.97)	105.60 (1.19)
DBP	62.82 (0.79)	63.80 (1.30)	63.24 (1.33)	63.21 (1.07)
HR	79.17 (2.31)	79.69 (2.57)	78.83 (2.44)	78.33 (1.65)

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* = 106 for all measures.

Table 2

Means and Standard Errors (in parentheses) of Blood Pressure and Heart Rate Reactivity Scores.

	Chosen Color		Assigned Color	
	Easy	Unclear Difficulty	Easy	Unclear Difficulty
SBP	5.38 (0.73)	3.79 (0.67)	6.30 (0.82)	3.69 (0.66)
DBP	4.96 (0.72)	3.02 (0.52)	4.27 (0.75)	2.84 (0.60)
HR[1]	7.07 (0.91)	4.02 (0.96)	6.40 (0.98)	3.92 (0.89)

Note. SBP = systolic blood pressure (in mmHg), DBP = diastolic blood pressure (in mmHg), and HR = heart rate (in beats/min). *N* = 106 for all measures.

[1] HR reactivity scores are baseline-adjusted.

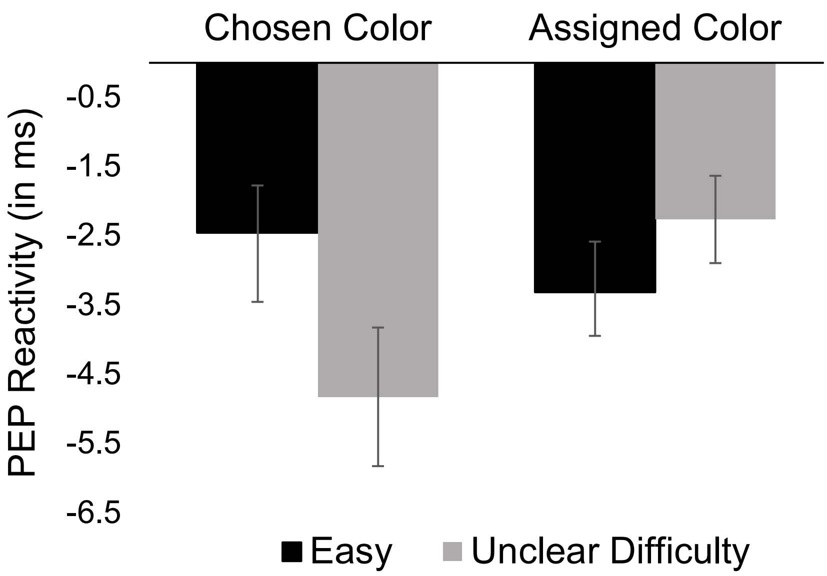
Table 3

Means and Standard Errors (in parentheses) of the Number of Correctly Remembered Letters.

Chosen Color		Assigned Color	
Easy	Unclear Difficulty	Easy	Unclear Difficulty
11.18 (1.32)	14.48 (0.80)	14.33 (0.83)	12.28 (0.99)

Note. Task Performance corresponds to the number of correctly remembered letters out of the 16 presented letters. $N = 106$.

Figure 1 *Cell means and ±1 standard errors underlying the combined effect of Color Choice and Difficulty on cardiac pre-ejection period (PEP) reactivity.* Shorter PEP reflects higher effort.



Online Supplementary Material

Choosing Task Characteristics Oneself Justifies Effort:

A Study on Cardiac Response and the Critical Role of Task Difficulty

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To give researchers a fuller picture of hemodynamic responses during task performance that were, however, not relevant for our hypotheses, we assessed and analyzed the responses of cardiac output (CO) and total peripheral resistance (TPR). CO was assessed with the ICG monitor and calculated by the Cardioscreen system according to the Sramek and Bernstein formula (see Bernstein, 1986). TPR was calculated from CO and mean arterial pressure (MAP = [2 x DBP + SBP] / 3) by using the formula TPR = (MAP / CO) * 80 (Sherwood et al., 1990). Given the lack of specific hypotheses about the responses of both hemodynamic indices, we first exploratively analyzed the cardiovascular responses with 2 (Choice) x 2 (Difficulty) ANOVAs.

CO and TPR Baseline Values

We constituted CO and TPR baseline scores by averaging cardiovascular values of the last 3 minutes of the habituation period, which showed high internal consistency during the last three minutes (Cronbach's αs > .99). Cell means and standard errors are displayed in

Supplementary Table 1.

Supplementary Table 1

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

	Chosen Color		Assigned Color	
	Easy	Unclear	Easy	Unclear
CO	5.92 (0.18)	5.94 (0.31)	5.59 (0.21)	5.46 (0.17)
TPR	1072.33 (33.41)	1109.19 (47.61)	1133.88 (32.23)	1164.15 (40.04)

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

Preliminary 2 (Choice) x 2 (Difficulty) ANOVAs of the baseline scores revealed no significant differences between the later conditions (*p*s > .074). Furthermore, we compared the baseline values of women and men with *t*-tests (including gender in the three-factorial ANOVA did not make sense because there were far more women than men in our sample). The gender analyses did not reveal any significant gender differences for CO or TPR baseline values (*p*s ≥ .525).

CO and TPR Reactivity

We created reactivity scores by subtracting the baseline values from the averaged 1-min scores of CO and TPR assessed during the task. Cell means and standard errors appear in Supplementary Table 2. Preliminary ANCOVAs found no significant associations between baseline and reactivity scores of CO or TPR ($ps \geq .409$). Moreover, *t*-tests revealed no gender differences for CO or TPR reactivity scores ($ps \geq .234$).

CO Reactivity. A 2 (Choice) × 2 (Difficulty) ANOVA of CO reactivity revealed neither significant main effects of Choice or Difficulty ($ps \geq .129$), nor a significant Choice x Difficulty interaction effect ($p \geq .709$). Also, the 3:1 a priori contrast that tested our predicted effort-related pattern was not significant ($p = .998$).

TPR reactivity. A 2 (Choice) × 2 (Difficulty) ANOVA of TPR reactivity found a significant Difficulty main effect, $F(1, 102) = 4.37$, $p = .039$, $\eta^2 = 0.04$, with higher reactivity in the Easy condition ($M = 17.13$, $SE = 8.01$) than in the Unclear Difficulty condition ($M = -1.83$, $SE = 5.44$). The Choice main effect and the interaction effect were both not significant ($ps \geq .117$). The 3:1 a priori contrast that tested our predicted effort-related pattern approached significance ($p = .057$). However, as presented in Table 2, TPR reactivity tended to be reduced in the Chosen Color/Unclear difficulty condition, in which PEP reactivity was stronger than in the other three conditions.

Supplementary Table 2

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

	Chosen Color		Assigned Color	
	Easy	Unclear	Easy	Unclear
CO	0.34 (0.06)	0.26 (0.05)	0.24 (0.06)	0.20 (0.03)
TPR	8.86 (12.58)	-8.53 (9.62)	26.77(9.17)	3.95(5.77)

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