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The moderating effect of success importance on the relationship between listening demand and listening effort

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ABSTRACT

A common element of the psychophysiological research on listening effort is the focus on listening demand as determinant of effort. The paper discusses preceding studies and theorizing on effort to show that the link between listening demand and listening effort is moderated by various variables. Moreover, I will present a recent study that examined the joint effect of listening demand and success importance on effort-related cardiovascular reactivity in an auditory discrimination task. Results for pre-ejection period reactivity—an indicator of sympathetic activity—supported the hypothesis that the relationship between listening demand and listening effort is moderated by other variables: Pre-ejection period reactivity was higher in the high-demand-high-success-importance condition than in the other three conditions. This new finding as well as the findings of previous research on effort suggest that a broader perspective on the determinants of listening effort is warranted.

INTRODUCTION

Research on listening effort has employed self-reports, behavioral measures, and physiological measures to draw inferences about listening demand and listening effort. Among the physiological measures that have been used are pupil dilation (e.g., Koelewijn et al. 2012; Kramer et al. 1997; Kramer et al. 2013; Kramer et al., this issue, pp. XXXX; Kuchinsky et al. 2013; Piquado et al. 2010; Zekveld & Kramer 2014; Zekveld et al. 2010), heart rate, skin conductance, skin temperature, EMG activity (e.g., Mackersie & Cones 2011), heart rate variability (e.g., Mackersie & Calderon-Moultrie, this issue, pp. XXXX), fMRI activity (Wild et al. 2012), ERPs (Obleser & Kotz 2011), and EEG alpha power (Obleser et al. 2012) (see McGarrigle et al. 2014, for a summary of listening effort studies using physiological measures published between 2008 and 2013). A common element of these psychophysiological studies on listening effort is that they examined the effects of variables related to listening difficulty on the physiological measures of interest. For instance, Zekveld et al. (2010) varied the signal-to-noise ratio of speech in noise and found a negative relationship between signal-to-noise ratio and pupil dilation. Researchers differed in the conclusions that they drew from the finding that a physiological measure changed in response to the manipulation of listening difficulty. Some researchers interpreted the observed changes as evidence that the physiological measure indicates listening effort or resource allocation (e.g., Koelewijn et al. 2012; Mackersie & Cones 2011; Obleser & Kotz 2011; Piquado et al. 2010; Wild et al. 2012). Other researchers suggested that this provides evidence for a physiological correlate of cognitive load or processing load (e.g., Kramer et al. 2013; Kuchinsky et al. 2013; Zekveld & Kramer 2014; Zekveld et al. 2010). This paper aims at challenging the first interpretation by pointing out that research on effort mobilization has demonstrated that the difficulty-effort relationship depends on many factors (see Pichora-

Fuller et al., this issue, pp. XXXX, for an extensive discussion of the various factors that affect listening effort). The demonstration of a relationship between a physiological measure and listening difficulty is therefore not sufficient to validate the measure as an indicator of listening effort.

One of the first authors acknowledging that the relationship between task difficulty and effort is not proportional was Kukla (1972). In his attributional theory of performance, he integrated empirical evidence that suggested that the proportional relationship between task difficulty and effort is limited by individual ability. Effort increases with increasing task difficulty but drops if task difficulty is too high. If it is impossible to succeed in a task, individuals disengage and do not invest any effort in the task. Drawing on Kukla's reasoning, one would expect a physiological indicator of listening effort not only to increase with listening demand but also to show no change (compared to a baseline) if listening demand exceeds the individual's ability.

Brehm (Brehm & Self 1989) introduced with motivational intensity theory a model that added further moderators of the link between task difficulty and effort. He suggested that individuals are motivated to conserve resources that are potentially important for survival. Defining effort as the investment of resources to overcome obstacles in goal pursuit (see Pichora-Fuller, et al., this issue, pp. XXXX, for a similar definition), Brehm concluded that effort investment is governed by a resource or energy conservation principle. Aiming at minimizing the waste of resources (or energy), individuals should invest only the amount of effort that is required for task success. It follows that effort investment should be a function of task demand: The higher the demand, the higher the required effort and the higher the effort investment. However, the resource conservation principle requires that the proportional relationship between task demand and effort is limited. According to motivational intensity theory, the upper limit of this relationship is determined by the individual's ability and the importance of success. If it is impossible to succeed, any effort investment would constitute a waste of resources and, consequently, individuals should not invest effort in impossible tasks. If the required effort exceeds the effort that is justified by the importance of success–that is, if the costs exceed the benefits–resource investment would also waste resources. Individuals should therefore not invest resources if the required effort exceeds the justified effort. In sum, motivational intensity theory predicts that effort is a function of task demand if task success is possible and if the required effort is justified. If task success is impossible or if the required effort is not justified by success importance, no effort should be invested.

These predictions should, however, only hold if task difficulty is known. If task difficulty is unknown, motivational intensity theory predicts that effort is a function of success importance: The higher the importance of success, the higher the effort. Given that individuals cannot use task demand to determine the required effort if task demand is unknown, they are at risk of wasting resources. Motivational intensity theory suggests that individuals use in this situation the importance of success to determine effort investment. This guarantees that one does not invest more resources than justified for task success. One might invest more than required but the costs will never outweigh the benefits.

The implications of motivational intensity theory's reasoning on the determinants of effort are straightforward. A valid physiological indicator of effort would need to reflect the joint effect of task demand and success importance under conditions of clear task difficulty as well as as the predicted effect of success importance under conditions of unclear task difficulty. There are already some empirical papers that tested motivational intensity theory's predictions using physiological measures (e.g., Gendolla & Wright 2005; Gendolla et al. 2012; Richter 2012; Wright 1996, for overviews). Drawing on a seminal paper by Wright

(1996), this research has used sympathetic-driven cardiovascular measures as indicators of effort. Having studied Obrist's work on active coping (e.g., Light & Obrist 1983; Obrist 1981), Wright suggested that effort is reflected in the effect of the sympathetic system on the heart. Any cardiovascular measure that reflects sympathetic effects on the heart would thus constitute a potential indicator of effort. Recent research has mainly relied on pre-ejection period—the time interval between the beginning of the excitation of the left heart ventricle and the opening of the aortic valve—as an indicator of myocardial sympathetic activity and effort, whereas older research has employed systolic blood pressure. Pre-ejection period is a direct indicator of the force of myocardial contraction and, given that myocardial contraction force is mainly determined by (beta-adrenergic) sympathetic effects on the heart, it reliably reflects changes in myocardial sympathetic activity (e.g., Harris et al. 1967; Newlin & Levenson 1979).

A demonstration of the non-linear relationship between task difficulty and effort–assessed as pre-ejection period reactivity (the change from rest to task performance)–can be found in Richter, Friedrich, and Gendolla (2008). They manipulated the difficulty of a Sternberg memory task across four levels and found a non-linear relationship between task difficulty and pre-ejection period reactivity. Pre-ejection period reactivity increased across the three possible task difficulty levels with increasing difficulty. However, pre-ejection period was low in the fourth difficulty condition where task difficulty was so high that task success was impossible. An example for the limiting effect of success importance can be found in Richter, Baeriswyl, and Roets (2012). In this study, participants performed either an easy or a difficult ambiguous categorization task. Drawing on their level of need for closure, participants were split into a group with a high need for closure and participants with a low need for closure. Both need for closure groups did not differ regarding the effort investment in the easy categorization task. Pre-ejection period reactivity was low and did not differ between the two groups. However, pre-ejection period differed between both groups if the categorization task was difficult. Given that individuals with a high need for closure are motivated to quickly resolve ambiguous situations, it was more important for the high need for closure group than for the low need for closure group to solve the ambiguous categorization task. The high required effort for the difficult categorization task was thus justified for the high need for closure group but not for the low need for closure group. Correspondingly, participants in the low need for closure group disengaged whereas participants in the high need for closure group invested effort and had a high pre-ejection period reactivity. The study of Richter and Gendolla (2009) constitutes an example for the effect of success importance on effort under conditions of unclear task difficulty. Participants performed a delayed-matching-to-sample task without knowing in advance the difficulty of the task. Success importance was manipulated by varying the monetary reward that participants could earn by successfully performing the task. The findings corroborated motivational intensity theory's predictions: Pre-ejection period increased across the three reward levels with increasing reward value.

One shortcoming of the preceding research on motivational intensity theory regarding the application of the research to listening effort is the lack of studies that involved auditory tasks. Research on motivational intensity theory has employed various mental tasks but the theory's predictions have never been tested using an auditory task. Even if there is no theoretical or empirical reason that suggests that listening effort is qualitatively different from effort in general (i.e., that the underlying mechanisms are different), empirical research that demonstrates that the theory's predictions also hold for listening effort is lacking. The study presented in this article aimed at providing first evidence for the moderating effect of success importance—manipulated by offering different levels of reward for a successful task performance—on the relationship between listening demand and effort investment.

For this purpose, participants performed four blocks of an auditory discrimination tasks while their cardiovascular activity (pre-ejection period, heart rate, systolic blood pressure, and diastolic blood pressure) was assessed. The four blocks differed regarding the difficulty of the auditory discrimination task (low vs. high) and the reward (low vs. high) that participants could earn by successfully performing the task. Drawing on motivational intensity theory's predictions and Wright's reasoning regarding the link between effort and cardiovascular responses, I expected higher pre-ejection period reactivity in the difficult-discrimination-high-reward condition than in the other three conditions. If discrimination difficulty is low, participants should invest low effort independent of the reward value and pre-ejection period reactivity should be low. If discrimination is difficult, the required effort should be justified in the high-reward condition but not in the low-reward condition. Individuals in the difficult-discrimination-low-reward condition should disengage and show low pre-ejection period reactivity, whereas individuals in the difficult-discrimination-high-reward condition should engage, invest high effort, and show high pre-ejection period reactivity. Heart rate and blood pressure were assessed for historical reasons—systolic blood pressure was the main dependent variable in the first studies on motivational intensity theory.

MATERIALS AND METHODS

Participants and Design

16 psychology students participated in the study for course credit (mean age = 23.88 years, 14 women and 2 men). All participants performed four blocks of an auditory discrimination task that differed in discrimination difficulty (easy vs. difficult) and reward (low vs. high). The participation was anonymous and voluntary.

Apparatus and Physiological Measures

Experiment generation software (Inquisit by Millisecond Software, Seattle, WA) controlled the presentation of the stimuli and instructions and collected participants' responses. Cardiovascular measures were collected using a Dinamap Carescape V100 (GE Healthcare, Buckinghamshire, UK) and a CardioScreen 1000 impedance cardiograph (medis, Illmenau, Germany). The Dinamap system assessed systolic blood pressure (SBP, in millimeters of mercury [mmHg]) and diastolic blood pressure (DBP, in millimeters of mercury [mmHg]) in intervals of two minutes using the oscillometric method. The system also determined heart rate (HR, in beats per minute [bpm]) in intervals of two minutes. The system's cuff was placed around the upper arm of the participant's non-dominant hand. The CardioScreen system used four pairs of disposable sport electrodes to assess an electrocardiogram (ECG) and thoracic impedance (impedance cardiogram, ICG) with a sampling rate of 1000 Hz (see Scherhag et al. 2005, for a validation of the system). The electrodes were placed on the left and right middle axillary line at the height of the xiphoid and on the right and left side of the base of the participant's neck.

The assessment of blood pressure and HR provided information about potential confounding effects on pre-ejection period (Obrist et al. 1987; Sherwood et al. 1990). Decreases in pre-ejection period (i.e., increases in pre-ejection reactivity) may be due to increased sympathetic effects on the heart. However, decreased pre-ejection period may also be the result of increased cardiac preload—increased ventricular filling—or decreased cardiac afterload—the load that opposes the ejection of blood into the aorta. Increased cardiac preload increases the force of myocardial contraction via the Frank-Starling mechanism, which leads to decreased pre-ejection period without concomitant changes in sympathetic activity. Decreased afterload reduces the time that is required to build up sufficient force to open the aortic valve and to eject the blood. Decreased afterload thus also results in a reduction of pre-ejection period that is not caused by sympathetic activity. Sherwood et al. (1990) and Obrist et al. (1987) suggested that HR and DBP indicate changes in preload and afterload. They recommended that decreased pre-ejection period is only interpreted as reflecting increased sympathetic activity if there is no parallel decrease in HR—a decrease in HR would suggest an increase in preload—and no parallel decrease in DBP–a decrease in DBP would suggest a decrease in afterload.

Auditory Discrimination Task

In each trial of the auditory discrimination task two sine waves with a frequency between 400 Hz and 500 Hz were presented one after the other and participants had to decide whether the two presented tones were identical or not by pressing one of two keys. Participants wore headphones throughout the experiment and could adjust the volume of the presented tones at any time. Each task trial started with a fixation cross presented on the monitor screen for 1000 ms. Then, a first sine wave was presented for 500 ms. 100 ms after the end of the first tone, a second sine wave was presented for 500 ms. Participants had then 3400 ms to enter their response. After they had pressed a key, a feedback on the accuracy of their response was shown for the remaining trial duration. Total trial duration was fixed to 5500 ms. The next trial followed after an inter-trial interval of 125 ms. If participants did not press a key within the response window of 3400 ms, the trial was scored as an incorrect response and a respective feedback was presented for the remaining trial duration.

The auditory discrimination task included three types of trials. The tone sequence could consist of the same tone presented twice, two sine waves that differed by 3 Hz, or two sine waves that differed by 20 Hz. Sequences consisting of tones that differed by 3 Hz were combined with sequences consisting of the same tone to yield blocks where discrimination was difficult (*difficult discrimination condition*). Sequences with tones differing by 20 Hz were used in combination with sequences consisting of the same tone to create blocks where discrimination was easy (*easy discrimination condition*). The same number of the two trial types was presented in randomized order within each block.

Procedure

The experiment was run in individual sessions. After participants had provided informed consent, the experimenter–who was hired and ignorant of the hypotheses–applied the blood pressure cuff and the CardioScreen electrodes, and participants indicated their sex and age. Participants then received a general description of the auditory discrimination task. They also learned that they would have the opportunity to practice the task by performing first a block of the easy discrimination condition and then a block of the difficult discrimination condition. Each practice block included 12 trials. After having performed the practice trials, participants' cardiovascular activity at rest was assessed during the next 10 minutes while participants could leaf through some magazines. During this baseline period, blood pressure was assessed in two-minute intervals starting three minutes after the beginning of the period. ECG and ICG signals were continuously assessed.

After the baseline period, participants were informed that they would work in the next minutes on four blocks of the auditory discrimination task. Each block would include 32 trials (for a total block duration of three minutes) either of the easy discrimination condition or of the difficult discrimination condition. Furthermore, participants learned that they could earn in each block either CHF 0.20 (about USD 0.20, *low reward condition*) or CHF 2 (*high reward condition*) by responding correctly in at least 90% of the block's trials. They then performed the four blocks of the auditory discrimination task. All possible combination of discrimination difficulty (easy vs. difficult) and reward (low vs. high) were presented in randomized order. Before each block participants were informed about the difficulty of the upcoming trials as well as about the reward that they could earn in the block. During each block, blood pressure was assessed in two-minute intervals starting ten seconds after the beginning of the block. ECG and ICG signals were continuously assessed. After having performed the four blocks, the experimenter carefully debriefed the participants and payed them the monetary reward that they had earned.

Data Analysis

R-peaks in the ECG signal were automatically identified using the algorithm proposed by Pan and Tompkins (1985). The positions of the detected r-peaks were visually confirmed and corrected if necessary. The ICG signal was differentiated and the resulting dZ/dt signal was filtered with a low-pass Butterworth filter (50 Hz cut-off frequency, Hurwitz et al., 1993). Ensemble averages over periods of 60 s (Kelsey & Guethlein 1990) were constructed using the detected r-peaks. A pre-ejection period value (PEP, in milliseconds [ms]) was scored for each ensemble average as interval between R-onset (onset of ventricual excitation) and B-point (aortic valve opening) following the guidelines by Sherwood et al. (1990). Baseline and task scores were computed for each cardiovascular measure by calculating the arithmetic mean of all measures obtained during the last three minutes of the baseline period and the three minutes of each task block. Cardiovascular reactivity scores were computed for each task block by subtracting cardiovascular baseline scores from the respective block scores (Llabre et al. 1991).

Given that the prediction about the joint effect of discrimination difficulty and reward value is not adequately captured by the tests of conventional 2 x 2 ANOVAs, a specific contrast tested the main hypothesis (Rosenthal & Rosnow 1985). Contrast weights were +3 in the difficult-discrimination-high-reward cell and -1 in the other three cells. Two (task discrimination) x 2 (reward value) repeated-measures ANOVAs were conducted to analyze task performance.

RESULTS

Task Performance

Providing evidence for the successful manipulation of task difficulty, the 2 x 2 ANOVA of the number of correct responses revealed a significant main effect of task difficulty, $F(1,15) = 121.03$, $p < .001$. The reward main effect and the interaction were not significant, $Fs(1,15) < 3.22$, $ps > .09$. The ANOVA of the reaction times of all task trials showed the same pattern. The task difficulty main effect was significant, $F(1,15) = 5.84$, $p = .03$, whereas the reward main effect and the interaction were not significant, $Fs(1,15) < 0.72$, $ps > .40$. Cell means and standard errors of reaction times, the number of correct responses, and the percentage of correct responses can be found in Table 1.

Cardiovascular Reactivity

Cardiovascular baseline values were as follows: $M = 105.23$ and $SE = 2.07$ for PEP, $M = 77.88$ and $SE = 2.83$ for HR, $M = 111.06$ and $SE = 2.15$ for SBP, and $M = 73.41$ and $SE = 1.76$ for DBP. The planned contrast was significant for PEP reactivity during task performance, $t(15) = 4.02$, $p < .001$. PEP reactivity was higher in the difficult-discrimination-high-reward cell than in the other three cells. Figure 1 displays this pattern. HR reactivity displayed the same pattern, $t(15) = 1.94$, $p = .04$. The planned contrast did not attain the critical alpha level of 5% for SBP and DBP reactivity, $ts(15) < 0.95$, $ps > .18$. Cell means and standard errors of all cardiovascular parameters can be found in Table 2.

Given that many studies on listening effort considered only task difficulty as determinant of listening effort, I additionally used the PEP data to compare the performance of a model that includes task difficulty as predictor of listening effort with the performance of a model that draws on motivational intensity theory and that includes task difficulty and success importance as predictors. The comparison of the unexplained sum of squares associated with the two models (see Glover & Dixon 2004; Masson 2011; Richter 2015, for a description of the analytical procedure) resulted in a Bayes factor of 14.65. Following the interpretation of Bayes factors by Raftery (1995), this provides positive evidence in favor of the joint effect of task difficulty and success importance predicted by motivational intensity theory, and against a model that only considers task difficulty as determinant of listening effort.

DISCUSSION

The presented findings underline the importance of considering factors in addition to listening demand when examining listening effort. The observed changes in PEP reactivity could not be explained satisfactorily by a model that included only listening difficulty. Under conditions of low listening demand, PEP reactivity was low. However, if listening demand was high, the level of reward (i.e., success importance) was crucial. If the reward (success importance) was high, PEP reactivity was high. If the reward (success importance) was low, PEP reactivity was low.

It is likely that these PEP changes reflect changes in sympathetic effects on the heart. Increases in myocardial sympathetic activity shorten PEP by means of increasing the force with which the heart contracts. Correspondingly, a decrease in PEP from rest to task performance potentially indicates an increase in myocardial sympathetic activity. However, given that decreases in PEP may also result from increased cardiac preload or decreased cardiac afterload, PEP changes need to be interpreted in the light of parallel changes in HR and DBP, indicators of changes in preload and afterload (Obrist et al. 1987; Sherwood et al. 1990). Given that neither HR nor DBP decreased from baseline to task performance, there was no evidence for preload or afterload changes that could explain the observed decrease in PEP. It seems thus likely that the observed PEP pattern reflects underlying changes in sympathetic activity and effort.

The presented findings do not only replicate preceding research on motivational intensity theory that has demonstrated the joint effect of task difficulty and success importance on effort (Barreto et al 2015; Richter et al. 2012; Silvia 2012, for recent examples). The findings are also highly relevant to the research on listening effort. They suggest that the strong focus on listening demand in the research on listening effort is unwarranted. Effort in general is not determined solely by task demand but by many factors and this probably also holds for listening effort. A more extended perspective on the determinants of listening effort would enable stronger links between the research on listening effort and research on other types of effort. The focus on task difficulty as determinant of effort has dominated the literature on effort in the first half of the 20th century (Ach 1935; Hillgruber 1912; Hull 1943; Zipf 1949) but in the last fifty years, researchers acknowledged the effect of other factors developing more complex models (e.g., Brehm & Self 1989; Eisenberger 1992; Kruglanski et al. 2012; Kukla 1972; Kurzban et al 2013; Nicholls, 1984) (see also Matthen, this issue, pp. XXXX). From the perspective of these models, the research on listening effort looks oversimplified and outdated. Extending the perspective on the determinants of listening effort will enable researchers to establish stronger links to other effort-related research and will probably result in a fruitful exchange between the research on listening effort and research on other types of effort.

An extended perspective on listening effort has also implications for the validation of physiological measures as indicators of listening effort. If listening effort is not a direct function of listening demand but is also affected by other variables (like success importance), validating a physiological measure as an indicator of listening effort needs more than the demonstration that the measure reflects manipulations of listening demand. It would be important to demonstrate that the physiological measure reflects changes in all variables that are supposed to exert an effect on listening effort. If one draws on motivational intensity theory, for instance, a valid indicator of listening effort should not only reflect the effect of listening difficulty but also the limiting effect of success importance, the disengagement if listening success is impossible, and the direct effect of success importance under conditions of unclear listening demand.

The approach presented above, and followed in many studies that aimed at validating a physiological measure as an indicator of a psychological state, is to draw on existing theoretical approaches and to take their hypothesis for granted. It makes, for instance, only sense to conduct a validation study that examines changes in a measure as a function of listening demand if one takes for granted that listening demand changes listening effort. It is noteworthy that this prevents the hypothesis that listening demand has an effect on listening effort. One can either take it for granted that listening demand changes listening effort or ask the question (formulate the hypothesis) whether listening demand changes listening effort. In other words, it is impossible to validate a physiological measure by manipulating listening demand and at the same time test the prediction that listening demand has an effect on effort.

There is a second approach to the validation of physiological indicators of listening effort that might be more promising. Instead of defining listening effort by the variables that affect it, one might separate the definition of listening effort from its determinants. The research on motivational intensity theory constitutes an example for such an approach. Wright's (1996) suggestion that effort is associated with myocardial sympathetic activity allowed researchers to work with a definition of effort that is independent of motivational intensity theory's predictions about the determinants of effort. Within such an approach, validation studies and studies testing the theoretical predictions are independent and do not interfere. In the context of motivational intensity theory, studies that validated PEP as an indicator of effort are studies that demonstrated that PEP is a valid measure of sympathetic effects on the heart (like the studies by Harris et al. 1967; Newlin & Levenson 1979, for instance). Studies testing the predictions of the theory were completely independent of these studies because they did not manipulate the criteria (sympathetic effects on the heart) that were used to validate PEP as an indicator of effort. The advantage of this approach is obvious. Defining listening effort without referring to its determinants, would enable researchers to conduct research on the determinants of listening effort without being limited by the validation studies. It would avoid situations where one has to decide between taking for granted the relationship between a factor and listening effort to conduct a validation study and testing the hypothesis that the factor has an effect on listening effort.

The research and the theories cited and presented in this paper point out that it is not sufficient to assess the effect of listening demand when examining listening effort. As also emphasized by the consensus paper (Pichora-Fuller et al., this issue, pp. XXXX), there are many more variables (like success importance, expected value, or social support) that have an effect on listening effort. A physiological indicator of listening effort would need to reflect changes in any of these variables. Moreover, broadening the perspective on the determinants of listening effort will facilitate the integration of the research on listening effort with other effort-related research leading to a better exchange of ideas.

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Table 1

Cell Means and Standard Errors (in parentheses) of Reaction Times, of the Number of Correct Responses, and of the Percentage of Correct Responses During the Four Blocks of the Auditory Discrimination Task

	Low Reward	High Reward
	Reaction Time	
Easy Discrimination	409.17 (60.91)	391.85 (38.13)
Difficult Discrimination	507.54 (47.03)	484.41 (55.66)
	Number of Correct Responses	
Easy Discrimination	29.31 (1.23)	30.25 (0.80)
Difficult Discrimination	19.31 (1.17)	20.63 (0.99)
	Percentage of Correct Responses	
Easy Discrimination	91.59 (3.84)	94.53 (2.50)
Difficult Discrimination	60.34 (3.66)	64.47 (3.09)

Note. Reaction time is in ms. $N = 16$.

Table 2

Cell Means and Standard Errors (in Parentheses) of Cardiovascular Reactivity During the Four Blocks of the Auditory Discrimination Task

	Low Reward	High Reward
	PEP Reactivity	
Easy Discrimination	-1.63 (1.22)	-1.33 (0.71)
Difficult Discrimination	-0.42 (0.56)	-2.46 (0.74)
	HR Reactivity	
Easy Discrimination	1.22 (1.03)	2.56 (1.06)
Difficult Discrimination	2.31 (1.54)	3.69 (1.14)
	SBP Reactivity	
Easy Discrimination	3.53 (0.93)	3.44 (1.03)
Difficult Discrimination	3.69 (0.81)	4.06 (1.07)
	DBP Reactivity	
Easy Discrimination	1.91 (0.88)	1.72 (0.90)
Difficult Discrimination	2.25 (0.96)	2.41 (0.83)

Note. PEP is in ms, HR in bpm, and SBP and DBP in mmHg. $N = 16$.

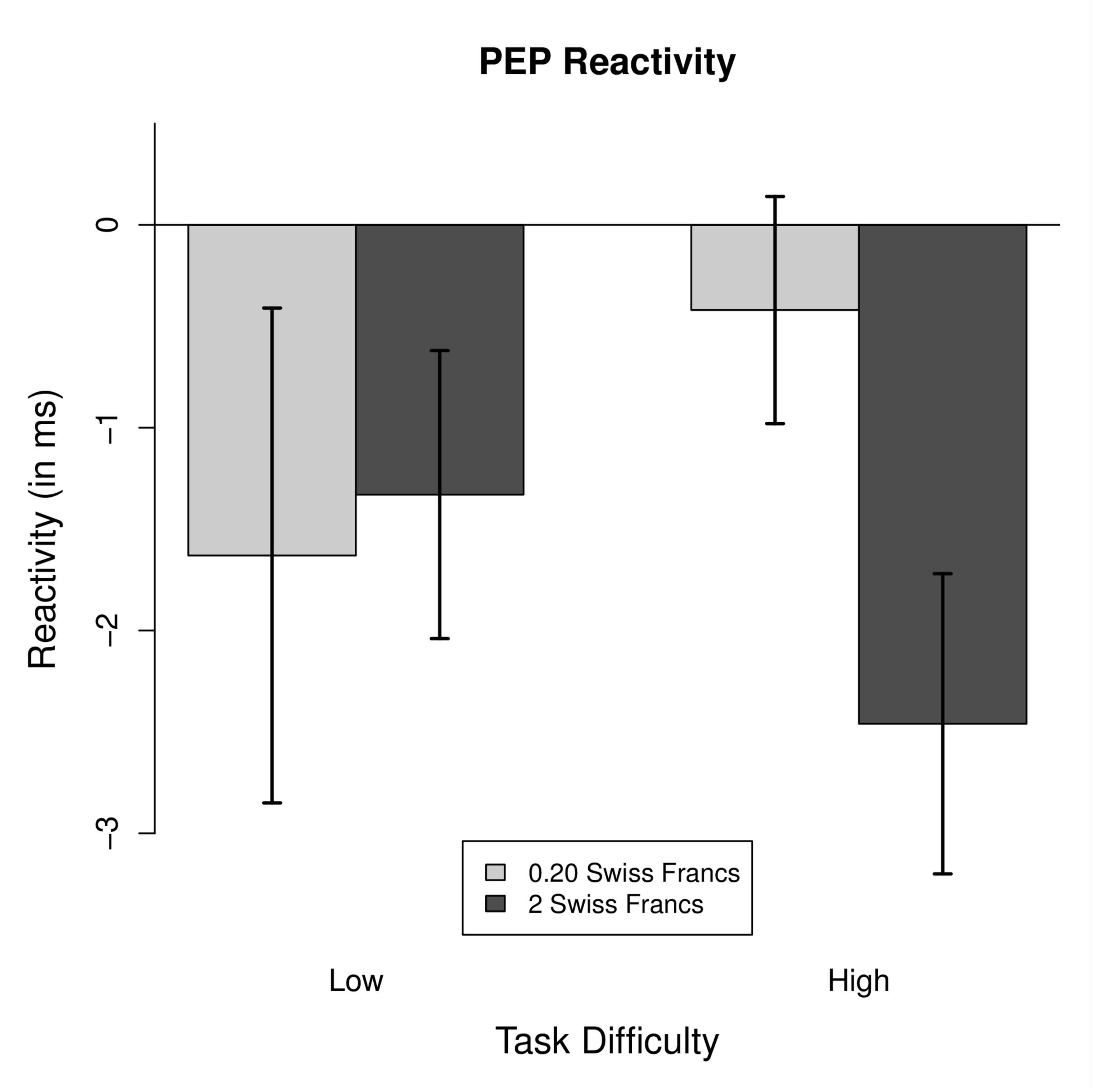

Figure 1. Mean PEP reactivity during the auditory discrimination task. Error bars represent standard errors of the mean.