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Physiological Indices of Anxiety and Self-Regulation Under Task Demands and Talk Aloud

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Physiological Indices of Anxiety and Self-Regulation Under Task Demands and Talk Aloud

By

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ABSTRACT

Anxiety shows differential reactions to stress across two distinct constructs: anxious apprehension and anxious arousal. Differences are related to bilateral resting state activity differences as measured by ECG and MRI studies, cognitive coping strategies measure via mismatch between anticipated and actual outcomes and across behavioral performance measures. Of note is the lack of extension of these terms to physiological domains other than measures of brain activity. It has been posited that the brain interacts in a top-down regulatory fashion with the autonomic nervous system to coordinate bodily reactions with environmental information to bring about changes in behavior. Given brain and behavioral differences found between anxious types, it is hypothesized that this will be reflected in differences across HRV and GSR, each of which acts as a measure of autonomic nervous system functionality. Participants were asked to self-report feelings of anxiety across measures of anxious apprehension and arousal. They were then exposed to self-regulatory demands through the Hamilton Letter Transformation Task. This involved the presentation of feedback to participants for each trial. A talk-aloud procedure was used to further connections between overt thought, the measures of interest, and task performance. It was found that there were significant mean differences consistent across constructs of GSR and HRV, namely by sex, work status, and both PSWQ and MASQ group assignment. Results were greatest for GSR indices. Significant interactions were specific to each physiological measure, namely between MASQ group assignment and work status for GSR indices and between MASQ group assignment and sex for HRV indices. Results showcase that there exists a relationship between anxious apprehension and arousal based on measures of the autonomic nervous system dependent on other independent variables for which they interact.

Keywords: GAD, HRV, GSR, anxiety, arousal, apprehension

Literature Review

Anxiety and GAD

Generalized anxiety disorder (GAD) is a widespread anxiety disorder characterized by chronic and persistent worry, which is excessive, difficult to control and is typically accompanied by other nonspecific psychological and physical symptoms (Stein & Sareen, 2015; DSM-V; American Psychiatric Association, 2013). GAD has an estimated prevalence of 3.1% in the United States and 5.7% prevalence over an individual's lifetime which is almost twice as high in women as it is in men (Kessler & Wang, 2008). Individuals with GAD also have increased risks of other mental and physical health conditions including, chronic pain syndromes, asthma, chronic heart disease, depression, and substance abuse disorders, among others (Sareen et al., 2006). These statistics are alarming and pose a difficult challenge for mental health practitioners in screening, diagnosing, and treating the disorder. The disorder can present itself both cognitively and somatically which can make it particularly debilitating with impacts across social and intimate partner relationships, ability to take care of everyday tasks, work life and balancing each of these areas of a person's life. For practitioners it can be especially difficult in formulating a diagnosis of anxiety given impacts on client's physical and mental health (Curtis et al., 2021). Current models of treatment emphasize the use of cognitive and behavioral interventions aimed at alleviating symptoms. This makes the focus of therapy to restructure the thoughts that lead to behavioral indicators of anxiety such that individuals feel more in control of their symptoms and lives (Brewin, 1996; Lorenzo-Luaces et al., 2016).

One of its most characteristic symptoms is a to react negatively to situations that are uncertain (Gentes & Ruscio, 2011). For instance, if an event takes place in the environment, the individual may think and feel that they do not know how to react, leading to uncertainty. What makes this symptom so difficult to manage comes from the means of coping that individuals use when working to deal with the uncertainty. For instance, many individuals internalize symptoms leading them to ruminate or repetitively think about the event (Curtiss et al., 2021). This is done for the person to be able to determine an appropriate action meant to help with the uncertainty that is caused by the event. This process, however, can be overactive in those with GAD due to a bias toward negative aspects of alternatives, causing them to assess other alternatives (Bar-Haim et al., 2007). One theory as to why this occurs comes from Beck's (1970) early conceptualization of cognitive therapy. In this theory, the thoughts and emotions that are evoked or brought on by a stimulus contact latent schemas that influence the way in which individuals process the initial GAD. Schemas are in essence conclusions that help to shape the world of the individual as they are integrated into their personality and behavior. For instance, the individual may have a schema that they are not intelligent which can make them feel that they are not able to adequately deal with a problem in their environment.

Anxiety and Cognitive Function

Across anxiety disorders there is a bias toward evoking negative schemas that hinder their ability to cope in other areas. This is the process known as appraisal which involves integrating aspects of an environmental stimulus which is meant to aid in the process of dealing with it in an appropriate manner. This process allows for the allocation of other cognitive resources that can help to coordinate behavior (Lorenzo-Luaces et al., 2016). These various processes are best known as executive functions and have long been shown to have deficits in those across anxiety disorders (Robinson et al., 2013).

Those with GAD have consistently shown a bias toward the processing of negative over positive information in their environment. The process of selecting what information is important in each situation makes up a proportion of attentional processes. Eysenck et al. (2007) contended that thoughts and feelings interact with the increased sensitivity to threat, which leads to differential responses to emotive stimuli. Other studies that have looked at this directly, found that this is the case by examining performance on attention-based tasks (Bar-Haim et al., 2007). In other words, depending on the current state of the individual, they have sensitivity to potential threats in the environment. Individuals with anxiety showcase decreased thresholds for information that can lead to threat related responding, which may operate in the brain through anticipation of what may or may not occur. Anxious individuals may anticipate more threats, priming the brain for threat detention which leads to directed attention toward negative features. This is best explained through work which has found that mismatch between anticipation and the presented outcome led to differential responses at the level of the brain. Specifically, anxious individuals have been shown to have increased startle in related responding to mismatched cues of auditory and visual stimulation (Nelson et al., 2015).

Anxious Arousal vs Anxious Apprehension

Looking beyond the differential functionality under anxiety provoking situations, anxiety has been shown to be further classified between two dimensions, anxious apprehension, and anxious arousal. Anxious Apprehension was initially conceptualized as a general sense of worry like state anxiety measures (Lehrer & Woolfolk, 1982.; Schwartz et al., 1978), however, as neuropsychological findings have been extended, it has become more associated as an additional dimension of trait anxiety (Sharp et al., 2015). In other words, it is a trait signifying a propensity to react to situations with worrisome thoughts and engage in safe behaviors that minimize risk. Anxious Arousal is defined as anxiety associated with action and has been associated with symptoms such as shortness of breath, high HR, dizziness, and sweating (Barlow, 1991; Heller et al., 1997; Nitschke et al., 1999). In other words, it is a trait signifying a propensity to have stronger reactions to threat related situations which is met with more directed behaviors meant to alleviate fear and anxiety.

Much of the research leading to differentiating these dimensions has focused on manipulations to task demands requiring the use of attentional control. This has involved poorer performance and decreased efficiency across self-report and experimental measures. (Engels et al., 2007; Eysenck et al., 2007; Nitschke et al., 1999). A paper by Sharp et al. (2015), nicely described studies which have pointed to this being the result of issues with shifting impairments for anxious apprehensive types (Snyder et al., 2014) and updating and inhibition dysfunction for anxious arousal types (Warren et al., 2021). Neuropsychological research has focused on EEG and fMRI studies that have looked at specific brain functionality differences between types. This work began with a finding of bilateral differences in prefrontal cortical activation such that anxious apprehension was associated with greater baseline left brain activity and anxious arousal was associated with greater baseline right brain activity (Heller et al., 1997; Nitschke et al., 1999). Beyond this, work has been focused on discovering other specific pattern differences of these terms to behavioral predispositions. This has led theorists to contend that differential activation across frontal brain areas have implications in apprehensive and approach behavior (Davidson et al., 2000; Heller et al., 1997). Research intended to aid in exploring these differences has focused on brain activity in response to incongruent feedback errors. Individuals with higher anxious apprehensive tendencies tend to react more intensely as measured through ERP research to negative feedback (Moser et al., 2013) while those higher in anxious arousal may have less adverse reactions due to activity in brain areas involved in threat detection (Engels et al., 2007). It has been proposed that processing inefficiency, stemming from the negative bias in anticipation and construal may be at play, with differential impacts on performance. Individuals who scored higher for arousal characteristics show overall better performance on tasks that incorporate feedback into their designs compared to those higher in apprehensive characteristics (Eysenck, 1985; Mueller et al., 1992). Despite these findings, an area of functioning that is related to brain functioning and which has seldom been explored in the context of these terms and executive functioning is the autonomic nervous system.

Autonomic Nervous System

The autonomic nervous system (ANS) is subdivided into the sympathetic (SNS) and the parasympathetic nervous system (PSNS). The SNS, known as the “fight-or-flight response" system, is active during activity and stress which controls several functions such as increased heart rate, increased respiration, conversion of glycogen to glucose, and secretion of adrenaline. The PNS, known as the "relaxed response" system, is responsible for relaxation and is responsible for decreasing heart rate, decreasing respiration, diverting blood flow to the gut, and constricting the bladder. In healthy individuals, the two systems work together in an alternating fashion to maintain balance in physiological autonomic function (Pham et al., 2021). Several studies have pointed to a relationship between emotions and ANS functionality. A systematic review of the literature by Kreibig (2010) found that ANS components measured via ECG, GSR, and Respiratory measures, among others could help to predict specific emotions. The review also looked at characterization of ANS activity for anxious individuals, which supported the simultaneous activation of the SNS and vagal deactivation. Outputs of the ANS such as ECG and GSR can therefore aid in the exploration of its impact in response to environmental events.

HRV is mediated by the autonomic nervous system from the interaction between the parasympathetic and the sympathetic inputs to the heart through the sinoatrial node (Thayer & Lane, 2000) and reflects the capacity for the parasympathetic nervous system to inhibit autonomic arousal. An increased HRV reflects a healthy autonomic nervous system that can respond to changing environmental circumstances (Thayer et al., 2009), and a decreased HRV is a marker of autonomic inflexibility. Individuals with anxiety show decreases in general HRV indices compared to controls (Kemp et al., 2012). Galvanic Skin Responses measure electrical conductivity of the skin. Such changes may be caused by events or emotional stimuli in the environment that cause the skin to sweat. GSR signals are referred to as a reliable biomarker of stress due to the influence of the SNS in regulating reactions to environmental stimuli (Ladakis & Chouvarda, 2021). Additionally, its responses are not stimuli or emotion specific but rather vary in intensity based on the experience of the emotion or stimuli (Boucsein, 1992).

Heart rate variability analysis can be conducted in the time domain, frequency domain, and by using non-linear analyses. The time-domain allows for the calculation of the standard deviation of all R–R intervals (SDNN) which reveals the components responsible for variability in the recording period, the root mean square of successive standard deviation (RMSSD) and the percentage of consecutive regular sinus RR intervals over 50 ms (pNN50) which both reflect vagal tone (Pham et al., 2021). The frequency domain differentiates ECG signals into ultra-low, very low, low, and high frequency domains. Ultra-low and very low frequency domains have been associated with long-term hormonal, circadian, and regulation mechanisms (Pham et al., 2021). Low frequency reflects a mix between the sympathetic and vagal influences and are considered a marker of cardiac outflow influenced by both sympathetic and parasympathetic branches of the autonomic nervous system (ANS). High frequency corresponds to parasympathetic cardiac activity which are linked to successful adaptation of the individual to changing environmental demands (Thayer & Lane, 2000).

The GSR signal can be distinguished into two different components. The conductivity level (SCL) reflects average skin conductivity in a period and is sensitive to slow changes in SNS activation. The conductivity response (SCR) reflects activation in response to single stimuli and thus is sensitive to quick changes in SNS activation (Ladakis & Chouvarda, 2021). In addition to SNS activation, GSR can act as an indicator of cognitive load and implicit brain activity which can be related to cognitive processes involved in self-regulation through correlations with other measures (Conway et al., 2013). One main issue with GSR data is that they are only a measure of arousal, and it is therefore recommended to utilize the analysis in the presence of other measures to aid in conclusions about total SNS activity.

Many studies have pointed to a link between ECG and GSR measures and anxiety with others extending this to create a direct link between these indices and decreased cognitive performance (Chattopadhyay et al., 1975; Hofmann et al., 2005; Holzman & Bridgett, 2017; Rappaport & Katkin, 1972; Thayer et al., 2012). An important aspect in this link is the connection between ANS outflow and the body's ability to calibrate reactions with contextually adaptive behavior to meet situational demands (Thayer & Lane, 2000). A reduction in vagal control (i.e., decreased HF-HRV) could be indicative of this, making the lack of ability to respond flexibly to changing demands characteristic of GAD, connected directly to ANS activity. This reduces the range of possible options, limits the individuals' ability to generate appropriate responses. An important theory that aids in this conclusion is the neurovisceral integration hypothesis, which points to brain areas involved in self-regulation through modulation of the vagus nerve (Thayer et al., 2012). This process has been implicated as a top-down regulatory process which incorporates pre-frontal cortical areas in activating the autonomic nervous system

(Hofmann et al., 2005; Holzman & Bridgett, 2017). GSR acts as a measure of the effects of implicit brain activity in the activation of the SNS with implications for those with GAD. Those with anxiety have shown greater fluctuations in skin conductance measures under no demands, with smaller slower responses to highly anxiety producing stimuli (Chattopadhyay et al., 1975). However, when considering individuals with high levels of trait anxiety, GSR indices increased more in response to threat when compared to low trait anxiety individuals (Rappaport & Katkin, 1972).

Anxious apprehension and arousal have less popularly been extended to ANS activity (Carter et al., 1986; Heller et al., 1997; Chalmers et al., 2013). What this does is create a gap in the literature that could potentially uncover the impacts of anxiety and these terms on the whole of the individual. In other words, by looking at impacts on the autonomic nervous system, a comprehensive understanding of these terms in categorizing anxiety may lead to establishing a link between the brain and body. Additionally, by looking at these connections in direct relation to executive functioning, it may be able possible that findings could be compared to currently unexplored findings of brain functionality.

Task and Surveys

To explore the connection between GAD and indices of ANS activity, it is important to select a cognitive task which induces anxiety in relation to self-regulatory demands. The Hamilton Letter Transformation Task can be differentially difficult based on the demands of each trial while requiring self-regulation when paired with feedback (Eysenck, 1985). This comes down to the nature of the demands of the task and the degree to which the environment allows for the usage of specific compensatory strategies. Additionally, findings suggested that anxious individuals often compensate for impaired processing efficiency with additional effort (Eysenck et al., 2007) with potential implications for differences in performance and ANS activity.

It has been shown that comorbid depression and anxiety tended to have compounding effects on decreasing HRV (Kemp et al., 2012) and GSR metrics (Markiewicz et al., 2022). To allow for connections made to GAD specifically, the Beck Depression Inventory (BDI) can help to evaluate key symptoms of depression. This is due to the BDI having excellent construct reliability and does well at aiding in identification of depression symptoms both in research and clinically (Beck et al., 1988). Two measures have consistently been used to measure anxious apprehension and arousal, the PSWQ and MASQ respectively. The PSWQ has been found to distinguish patients with generalized anxiety disorder (GAD) from other anxiety disorders in clinical and non-clinical settings (Meyer et al., 1990) and been reliably used to measure levels of anxious apprehension in research settings (Heller et al., 1997; Nitschke et al., 1999). The Mood and Anxiety Symptom Questionnaire (MASQ) has a direct measure of anxious arousal and has reliably shown to be a measure of the construct (Davidson et al., 2000; Heller, 1997; Nitschke, 1999; Watson et al., 1995).

Talk-Aloud

Talk Aloud is defined as a concurrent technique in which an individual is asked to verbalize his or her self-talk aloud while simultaneously performing a pre-determined task (Arnkoff & Glass, 1989; Genest & Turk, 1981; Martzke et al., 1987). Talk Aloud has the advantage of reducing memory and reporting bias compared to traditional thought listing cognitive methods and is more overt (Blackwell et al., 1985). It also yields a large sample for analyses (Merluzzi & Boltwood, 1989), making it a more feasible and pertinent measure of cognitive function. Talk Aloud was also related to increases in performance for individuals. However, these results could be due to increases in analytical task related self-talk (Lodge et al., 2000) and it may hinder performance (Blackwell et al., 1985). Ultimately, there may be a connection between talk-aloud, HRV and GSR, and performance with implications self-regulation training as a treatment for cognitive symptoms related to GAD when requiring positively valanced self-talk.

Research Questions and Hypotheses

This research has led to the development of three research questions. The 1st is whether there are differential physiological reactions dependent on anxious type compared to controls. The second pertains to the nature of the reactions under task demands and feedback requiring self-regulation. The final question is whether talk-aloud and usage of positive self-talk in particular aid in bringing autonomic responses closer to that of those without anxiety. It is hypothesized that HRV decreases while GSR increases for all participants. This is due to research that states that in any case an individual under environmental demands and stress must recruit resources meant to aid in effectively coping with the stress and demand. These changes should be greatest for anxious individuals with anxious apprehensive types having greatest effects in HRV while anxious arousal types showcase greatest changes in GSR metrics. These should also be met with decreased performance, which is greatest for anxious participants, which are dependent on the difficulty of each trial. Additionally, changes in task requirements via manipulations of the talk-aloud procedure should result in less change for both experimental manipulations.

Method

Participants

Participants were college students at Minnesota State University Mankato and were asked to first complete a survey which would be used as a pre-screening tool. The survey was presented using Qualtrics and sent out over the Minnesota State University Mankato's psychology experiment database, SONA systems. Included in the survey was a list of questions pertaining to demographic information, the Beck Depression Inventory (BDI), the anxious apprehension scale questions of the Mood and Anxiety Symptoms Questionnaire (MASQ), the Penn State Worry Questionnaire (PSWQ), and questions pertaining to an array of health-related behaviors. Like Heller et al. (1997), the PSWQ was selected as a measure of anxious apprehension while the MASQ was selected as a measure of anxious arousal. The BDI was used as a control for the effects of depression on the physiological measures of interest. Health behavior questions asked about history of heart conditions and psychiatric disorders, nicotine, alcohol, and caffeine usage, sleep per night, and how much participant's typically exercise in a week.

Participants who completed the survey were told that following analysis of the data that they could be selected to complete the in-person portion of the experiment. Initially it was intended that participants would be selected if they met specific criteria.

However, due to issues with recruitment for an in-person portion of the experiment, all participants other than those who had known heart conditions (*N*= 1) were given the opportunity to participate for a $10 gift card.

Survey data collection yielded a sample of 42 participants that completed at least part of the survey. The data were then trimmed using a Case-Wise deletion for participants that did not complete more than 50% of the total survey. This yielded a sample of 40 participants that were used as a reflection of the total participant pool in demographic analysis. Of these 40 participants a total of 15 participants completed the ECG and GSR data collection portion of the experiment making up the sample participant pool in analysis. The total age ranged between 18-44 years old with a mean of 22.5 years old (*SD*= 5.86). The sample age ranged between 18-30 years old with a mean of 22.53 years old (*SD*= 3.11). Data summarizing these results can be found in **Table 1**. **Table 2** summarized the total and sample results by sex, race, and whether participants worked while in school. In the total participant pool, most participants were female (82.5%), white (65%), and worked while in school (52.5%). Of those sampled, a majority of participants were white (66.67%), however males (40%) and females (60%) and those that did (53.33%) and didn't (46.67%) work were more closely split. Mean hours worked per week of the total pool was 12.05 hours per week (*SD*= 14.59) and of the sample pool was 12.53 hours per week (*SD*= 15.85). Hours worked per week ranged between 10-40 hours for both groups. A summary of these findings can be found in **Table 3**. Across both the total and sample pools, most participants showed no psychiatric disorder presentation (total= 67.5%, sample= 73.33%) or use of medications (total= 77.5%, sample= 86.67%).

A summary of these findings can be found in **Table 4**. Most participants in the final sample did not consume nicotine (73.33%), alcohol (86.67%), or caffeine (67.67%), exercised moderately (80%) and slept between 7+ hours per night (60%).

Table 1

Means and Standard Deviation of Age Across All Those Surveyed and Final Sample

Statistic (Years)	**Total**	**Sample**
M	22.5	22.53
SD	5.86	3.11
Range	18-44	18-30

Note. Mean, SD, and Range statistics for age of all participants and those in the in-person sample.

Table 2

Number of Participants Across All Those Surveyed and Final Sample for Sex, Race, and Working

	Sex		Race				Work	
Statistic (*N*)	**Males**	**Females**	**White**	**African American**	**Asian**	**Biracial**	**Yes**	**No**
Sample	6	9	10	1	3	1	8	7

Total	7	33	26	3	6	5	21	19

Note. Number of participants categorized by sex, race, and work status for all participants and those in the in-person sample.

Table 3

Means and Standard Deviation of Hours Worked Across All Those Surveyed and Final Sample

Statistic	**Total**	**Sample**
M	12.05	12.53
SD	14.59	15.85
Range	10-40	10-40

Note. Mean, SD, and Range statistics for hours worked of all participants and those in the in-person sample.

Table 4

Number of Participants Across All Those Surveyed and Final Sample for Disorder Presentation and Medications Used

	Disorder							Medication				
Statistic (*N*)	**None**	**Depression**	***Anxiety***	***ADHD***	***Anxiety and Depression***	***Other***	***Unspecified***	**None**	**Birth Control**	**Depression**	**ADHD**	**Other**

Sample	11	0	0	1	2	1	0	13	0	0	1	1
Total	27	2	1	1	6	1	2	31	3	3	1	2

Note. Number of participants categorized by disorder and current medications for all participants and those in the in-person sample.

In-Person Data Collection

Upon coming to the lab, participants went over the informed consent form and were given information as to what they would be doing throughout the session. Following this they were fixed with a 12-lead Holter monitor for ECG data acquisition. This was done utilizing a 12-lead Holter monitor from Viatom Technologies. The ECG electrodes were arranged using a 6-lead electrode system. This consisted of electrodes placed at LL, RL, RA, LA, V1, and V2. A diagram depicting the placement of electrodes can be found in **Appendix I**. Prior to application the area around electrode placement was cleaned using standard alcohol prep pads to prepare the area and minimize the influence of sweat in the acquired signal. Additionally, 2 electrodes were placed on the 1^{st} and 2^{nd} fingers of their non-dominant hand for GSR data acquisition. Data were acquired using a NeuLog GSR module which was calibrated at the factory prior to being shipped for experiment usage. Participants began the session with a 5-minute window of data collection as a baseline. This involved staring at a fixation cross on screen using the psychological experiment building program, OpenSesame. The time of collection was selected as it was similar in duration to the time it would take participants to complete the task introduction components of the experiment. A similar procedure was conducted following completion of all task introduction components of the experiment as a return to baseline.

The cognitive task was constructed and presented using the same experiment builder used in baseline and return to baseline phases. Each participant completed 60 trials, spread across 3 separate task introductions consisting of 20 trials each. There were differing task demands added to each of the 3 task introductions. For the 1^{st} task introduction, participants were asked to complete all transformation in their head without the use of talk-aloud to complete. The 2^{nd} task introduction consisted of participants being asked to talk aloud throughout task completion. The participants were prompted to talk aloud all thoughts, feelings, and emotions pertaining to the task however they saw fit, and which included the ability to talk specifically about the transformations they were performing. The 3^{rd} task introduction consisted of participants again being asked to talk aloud throughout completion with the additional demand being to utilize positive affirmation statements throughout the process. To aid in this, participants were given a list of statements that could be helpful and told that they could additionally utilize their own statements so long as they were positive. They were allowed to continue to perform the transformation aloud throughout this process as well. The list of affirmation statements provided can be found in **Appendix II**.

The task involved the presentation of a prompt card consisting of 3 random letters from the alphabet shown side by side. A seed card indicated the number of sequential letters each of the letters of the prompt card was to be transformed, making up the task demands for each trial. These ranged in value from +1 to +4 which were evenly and randomly dispersed throughout the 20 trials of each task introduction. The participant was asked to move each letter of the prompt card the specified number of letters of the seed card that were sequential to each specific letter. For example, if the participant was given a prompt card consisting of the letters F, N, and V and a seed card denoting a +2 transformation, the participant would transform to the correct answer of H, P, and X. Prompt and seed cards were random and different for each trial and across each of the task introductions to limit order effects of presentation within and across task introductions. Participants were given 3 response options that they were able to click when they derived what they thought to be the correct answer. A sample of the screen presented to the participant along with instructions on how to complete the task can be found in **Appendix III**.

Participants were given a total of 15 seconds to complete each trial. After each trial, participants were given feedback in the form of a green or red dot in the middle of the screen indicating if they got the preceding trial correct. A red dot was placed on the screen if they additionally did not select an answer in the allotted time. Feedback was presented for a total of 1.5 seconds followed by a break screen of another 1 second consisting of a fixation cross. This 1 second washout period was to allow for GSR responses to the feedback to be incorporated into analysis for each trial and accurate logging of the data into an excel file for later analysis. As the task was completed, data pertaining to the time to complete each trial and whether they got each question correct were collected by the experiment builder for use in subsequent analysis. Between task introductions, participants were given a 5-minute window of rest to help bring them back to baseline before subsequent recordings.

ECG and GSR Data

ECG data were captured across the interval of baseline, each task introduction, and subsequent return to baseline. At the start of each interval, the Holter monitor was started and remained in recording mode until the interval was completed. Data was then uploaded to the monitor's provided AI-powered ECG analysis software, Livenpace, for analysis. The analysis software conducted all ECG data analysis, yielding HRV data across 6 domains of interest for the experiment. These consisted of SDNN, RMSSD, and PNN50 in the time domain and LF, HF, and VLF in the frequency domain. The results of the analysis were taken from the reports provided and entered an excel file for later analysis.

GSR data were captured over the course of the baseline, within each trial interval of the three task introductions, and over the course of the return to baseline. Prior to the experiment the sensor was connected to the provided NeuLog api program such that it could synced with the experiment builder in time with the experiment. The sample range was set between 0 and 50 μSiemens at a sampling rate of 10 Hz. Data were exported into MATLAB files which included time-based indicators of trial duration and imported into Ledalab, a validated MATLAB based statistical software for GSR analysis (Benedek & Kaernbach, 2010a; Benedek & Kaernbach, 2010b). Data were first down-sampled to 5 Hz before adaptive smoothing using the Gauss method was applied. Down-sampling was used to conserve memory and processing time of the data without risk of losing important aspects of the signal. Adaptive smoothing was used to reduce artifacts in the data that may not be due to true changes in electrodermal activity. This is in line with procedures outline in Aqajari et al. (2020). Following this, CDA analyses, done according to Benedek and Kaernbach (2010a), were conducted across each of the 20 trials for a particular task introduction, optimized to two different sets of initial values. This yielded six components of the GSR signal for each trial including the Latency of Response onset (Latency), total amplitude sum (Amp Sum), the average phasic component over the interval (SCR), the area of the phasic driver within the interval (ISCR), the maximum phasic activity value in the interval (Phasic), and the mean tonic activity of the interval (Tonic). Data was then exported into an excel file for further analysis with other variables of the study.

Qualitative Data

Throughout both task introduction 2 and task introduction 3, qualitative data pertaining to participant's talk aloud were recorded. Talk-aloud data was collected by observers for the total amount of talk aloud, which were grouped like that of Lodge et al. (2000). This included talk-aloud across six qualitative categories: Positive, Negative, Neutral, Analytic, Directive, and Questioning. Any instance of verbal behavior resulted in a tally for that instance in its appropriate grouping. This yielded total numbers of verbal behavior across each category to be assessed in IOA agreement analyses.

Both total and weighted total agreement data were assessed for Task Introduction 2 and Task Introduction 3 for 12 out of 15 total participants. 3 participants were omitted as only one of the experimenters was available to conduct the session for each participant. Total agreement on instances of verbal behavior were assessed as a proportion of observer one's total tallies within the task interval over those of observer two's total tallies. Whichever observer's tallies was lower was placed in the numerator of the equation. Total weighted agreement was calculated as a proportion of Agreements / (Agreements + Disagreements) between observers. Agreements were calculated based on the number of shared observations of verbal behavior between observers across each of the 6 categories assessed which were then summed together. Disagreements were calculated as the difference between tallies of observer 1 and observer 2 for each of the 6 categories of verbal behavior assessed which were then summed together. For example, if observer 1 tallied 5 instances of behavior and observer 2 tallied 4 instances of behavior, they agreed on 4 instances and had 1 disagreement.

Data Analysis

All data were analyzed using R-Studio. This allowed for an analysis of demographic and survey data both across the total participant pool comprised of all participants who completed the survey and the sample participant pool comprised of those who completed both the survey and in-person session of the experiment. This involved an analysis of distributions, means, and comparison between the total and sample participant pools. IOA agreement was analyzed using an excel spreadsheet. Following this a MANOVA analysis with follow-up linear regression analyses of between task introduction differences for GSR metrics was used to predict GSR measures based on seed card number and task introduction, the interaction of responses to the MASQ and PSWQ, task performance, and each of the demographic and health behavior variables of the study. Talk aloud metrics were included in a separate analysis of differences between task introduction 2 and task introduction 3 and analyzed in a similar manner. Analysis of the ECG data was conducted in a similar manner as that of the between task introduction analyses of the GSR data. Baseline and Return to Baseline data for GSR were omitted due to incompatibility with trial by trail GSR analysis and the unreliability of averaged GSR measures for comparison to each task introduction.

Results

Survey Analysis and IOA Statistics

Given the initial intent of the study to differentiate between participants based on 3 surveys prior to completing ECG and GSR data collection, an analysis of each survey and tests for difference between total and sample participant pools were conducted. BDI results indicated a mean of 30.5 (*SD*= 9.06) for the total pool and 28.67 (*SD*= 6.42) for the sample pool. A Welch corrected independent samples t-test was conducted to assess differences in means yielding no significant difference between total and sample participant pools, $t(37.00) = -1.10$, $p = 0.28$. Cronbach's alpha score indicated high levels of internal consistency, $\alpha = 0.92$. MASQ results indicated a mean of 35.75 (*SD*= 8.88) for the total pool and 35.47 (*SD*= 6.41) for the sample pool. A Welch corrected independent samples t-test was conducted to assess differences in means yielding no significant difference between total and sample participant pools, $t(37.45) = 0.15$, $p = 0.88$. Cronbach's alpha indicated high levels of internal consistency, $\alpha = 0.80$. PSWQ results indicated a mean of 45.68 (*SD*= 10.51) for the total pool and 45.93 (*SD*= 10.12) for the sample pool. A Welch corrected independent samples t-test was conducted to assess differences in means yielding no significant difference between total and sample participant pools, $t(32.24) = 0.14$, $p = 0.89$. Cronbach's alpha indicated high levels of internal consistency, $\alpha = 0.78$. **Table 5** offers a summary of the results of survey analysis and participant pool comparisons.

As an additional measure of study structure and given the presence of qualitative data collection pertaining to talk-aloud metrics, IOA agreement data were assessed. Both total and weighted total agreement data were assessed for Task Introduction 2 and Task Introduction 3 for 12 out of 15 total participants. 3 participants were omitted as only one of the experimenters was available to conduct the session for each participant. For Task Introduction 2, IOA ratings ranged between 65-100% and 50-100% for total and weighted total agreement respectively. Mean total agreement was 88% (SD= 13.99%) and mean weighted total agreement was 74% (SD= 13.74%) for Task Introduction 2. For Task Introduction 3, IOA ratings ranged between 62-100% and 33-100% for total and weighted total agreement respectively. Mean total agreement was 88% (SD= 10.50%) and mean weighted total agreement was 76% (SD= 18.58%) for Task Introduction 3. Data summarizing these findings can be found in **Table 6**.

Table 5

Means, Standard Deviations, Alphas, and Comparison Statistics for the BDI, MASQ, and PSWQ Surveys

	BDI	MASQ	PSWQ

Statistic	Total	Sample	Total	Sample	Total	Sample
M	30.5	28.67	35.75	35.47	45.68	45.93
SD	9.06	6.42	8.88	6.41	10.51	10.12
Alpha	0.92		0.80		0.78	
t-statistic	-1.10		0.15		0.14	
df	37.00		37.45		32.24	
p-value	0.28		0.88		0.89	

Note. Mean, Standard Deviations, Alpha, and comparison statistics between all participants and those in the in-person sample for the BDI, MASQ, and PSWQ. Participants reported low mean BDI which did not significantly differ between total and in-person samples, $t(37.00) = -1.10$, $p = 0.28$. Participants showed low-moderate levels of anxious arousal which did not significantly differ between total and in-person samples, $t(37.45) = 0.15$, $p = 0.88$. Participants showed moderate levels of anxious apprehension which did not significantly differ between total and in-person samples, $t(32.24) = 0.14$, $p = 0.89$.

Table 6

Means of IOA Statistics for Talk-Aloud Metrics Across Task 2 and Task 3 Introductions

	Task 2	Task 3

Statistic	**Total Agreement**	**Weighted Agreement**	***Instances of Talk-Aloud***	**Total Agreement**	**Weighted Agreement**	***Instances of Talk-Aloud***
M	88%	74%	23.20	88%	76%	31.13
SD	13.99%	13.74%	10.50	10.50%	18.58%	11.46
Range	65-100%	50-100%	4-45	62-100%	33-100%	12-48

Note. Mean, SD, and Range statistics for total agreement, weighted total agreement, and instances of talk-aloud across task introductions 2 and 3.

Between Task GSR Differences

A factorial MANOVA was used to determine the effects of several independent measures on each of the GSR metrics captured in the CDA analysis. Significant main effects were determined to be significant based on task introduction ($F(2, 655)= 0.46$, $p< 0.001$), MASQ ($F(1, 655)= 0.37$, $p< 0.001$), PSWQ ($F(1, 655)= 0.64$, $p< 0.001$), sex ($F(1, 655)= 0.53$, $p< 0.001$), work status ($F(1, 655)= 0.89$, $p< 0.001$), exercise ($F(2, 655)= 0.27$, $p< 0.001$), sleep ($F(2, 655)= 0.34$, $p< 0.001$), and caffeine ($F(1, 655)= 0.29$, $p< 0.001$). The only non-significant main effect was found for seed card number, $F(3, 655)= 0.97$, $p= 0.24$. There were several interaction effects which were explored for each individual GSR metric through follow-up ANOVA analyses to explore these effects for each metric separately. Trial based calculations were excluded because it had effects on limiting degrees of freedom. In the analysis of the ANOVAs ISCR and SCR were determined to reflect the same measure given the same values for all ANOVA statistics across the same independent variables. Therefore, these were treated as a single test and only ISCR data were utilized in follow-up analyses.

Follow-up ANOVA for latency yielded significant main effects based on task introduction with increased latencies for task introductions 2 and 3 ($p< 0.001$), work status with those who did not work being higher ($p< 0.001$), and exercise with those that had high levels of exercise intensity showing decreased latencies ($p= 0.0033$). Interaction effects were found between MASQ and PSWQ group assignment, the MASQ and participant sex, between task intro and exercise, and between the MASQ, PSWQ, and task introduction. The ANOVA for amp sum yielded significant main effects based on MASQ which were higher for those who were below the mean on the MASQ ($p< 0.001$), work status which were higher for those that worked ($p< 0.001$), and exercise which were higher for those that exercised in the moderate-high and high intensity ranges ($p= 0.0033$). Interaction effects were found between the PSWQ and sex, the PSWQ and MASQ and the MASQ and work status. The ANOVA for ISCR yielded significant main effects based MASQ which was higher for those who had MASQ scores below the mean ($p< 0.001$), sex which was higher in females ($p< 0.001$), and exercise which was higher for those that exercised in the moderate-high and high intensity ranges ($p< 0.001$). Interaction effects were found between MASQ and PSWQ group assignment, the MASQ and participant sex, and between the MASQ, PSWQ, and task introduction. Summaries of means and standard deviations for main effects can be found in **Table 7**. The ANOVA for the phasic component yielded significant main effects based on the MASQ which were higher in those who scored above the mean on the MASQ ($p < 0.001$), the PSWQ which were higher in those who scored below the mean on the PSWQ ($p = 0.0012$), sex which were higher in females ($p < 0.001$), and exercise which showed an increasing trend as amount of exercise increased. Interaction effects were found between the MASQ and work status group assignments. Summaries of means and standard deviations for these main effects can be found in **Table 8**. **Figures 1-3** offer a graph of the meaningful interactions for each variable apart from interactions between MASQ and work status. This is due to a general trend signifying that those who showed high MASQ scores tended to have greater reactions across metrics when they did not work compared to those that worked. An adjusted *p*-value of 0.01 was used to determine significance.

Follow-up ANOVA for the tonic component yielded significant main effects for all variables and for all possible interactions between variables apart from those three. Given the unreliability of such a conclusion, these data are not reported here but reasoning as to why this is will be examined later in this paper.

A factorial MANOVA that aimed to add the effects of talk-aloud to the previous model was conducted and determined to show significant main effects for MASQ ($F(1, 444) = 0.43$, $p < 0.001$), PSWQ ($F(1, 444) = 0.73$, $p < 0.001$), task introduction ($F(1, 444) = 0.90$, $p < 0.001$), sex ($F(1, 444) = 0.44$, $p < 0.001$), work ($F(1, 444) = 0.76$, $p < 0.001$), exercise ($F(2, 444) = 0.27$, $p < 0.001$), and talk aloud ($F(1, 444) = 0.96$, $p < 0.001$) but not seed card number, $F(3, 444) = 0.94$, $p < 0.001$. There were several significant interactions, however, results of subsequent follow-up ANOVAs yielded models that showed little to no difference in models that did not incorporate talk aloud.

Table 7

Summary of Group Mean Differences for Latency, Amp Sum, and SCR/ISCR Components Based on Independent Measures

	Latency		Amp Sum		ISCR	
Statistic	***M***	***SD***	***M***	***SD***	***M***	***SD***
Low MASQ	-	-	0.13	0.22	0.66	0.86
High MASQ	-	-	0.076	0.11	0.42	0.53
Task Intro 1	1.41	1.29	-	-	-	-
Task Intro 2	1.82	1.31	-	-	-	-
Task Intro 3	1.89	1.21	-	-	-	-
Work	1.52	1.19	0.15	0.22	-	-
Do Not Work	1.90	1.36	0.082	0.16	-	-
Male	-	-	-	-	0.37	0.53
Female	-	-	-	-	0.70	0.86

Low-Moderate Exercise	1.73	1.35	0.071	0.11	0.38	0.48
Moderate-High Exercise	1.79	1.18	0.16	0.22	0.75	0.90
High Exercise	1.42	1.34	0.15	0.27	0.75	1.00

Note. Means and standard deviations differences for each of the main effects across the latency, amp sum, and ISCR components in GSR analysis.

Table 8

Summary of Group Mean Differences for the Phasic Component Based on Independent Measures

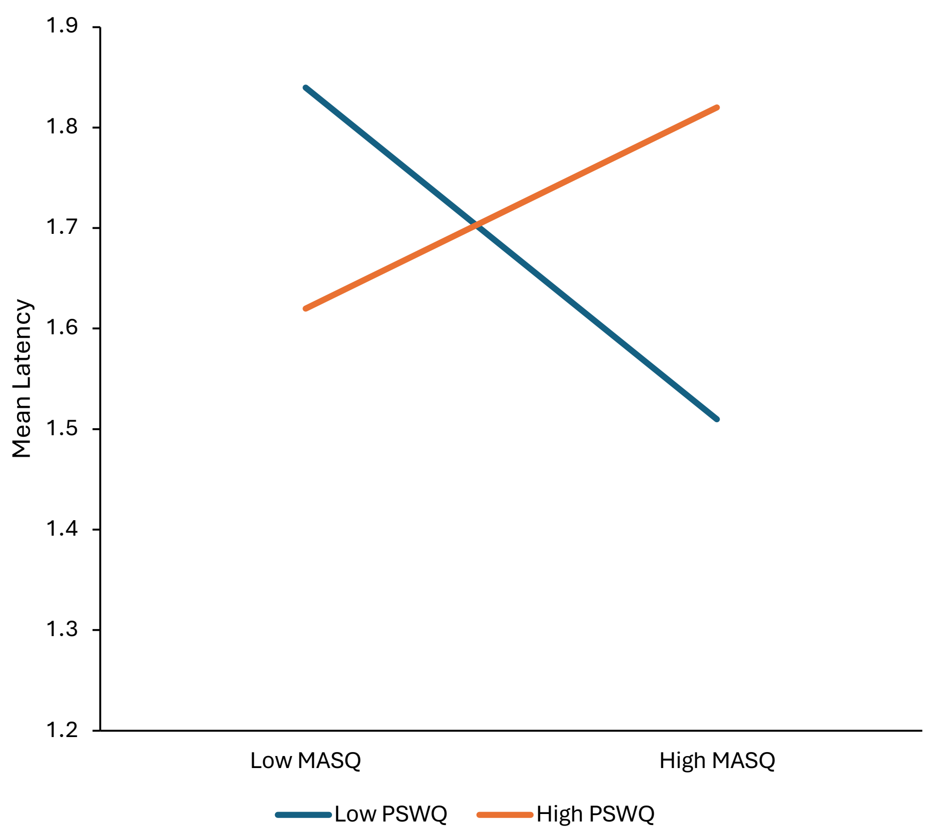
Statistic	***M***	***SD***
Low MASQ	0.55	0.60
High MASQ	0.37	0.39
Low PSWQ	0.45	0.58
High PSWQ	0.56	0.52
Male	0.33	0.42
Female	0.59	0.59

Low-Moderate Exercise	0.35	0.36
Moderate-High Exercise	0.59	0.60
High Exercise	0.68	0.75

Note. Means and standard deviations differences for each of the main effects across the latency, amp sum, and ISCR components in GSR analysis.

Figure 1

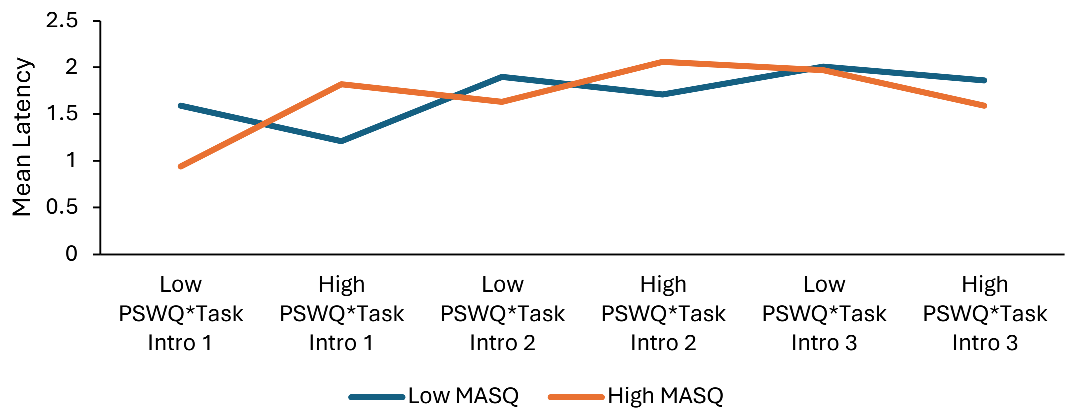
Latency Difference Interaction Between MASQ and PSWQ Group Assignment



Note. Graph of the interaction between PSWQ and MASQ group assignment for the latency component.

Figure 2

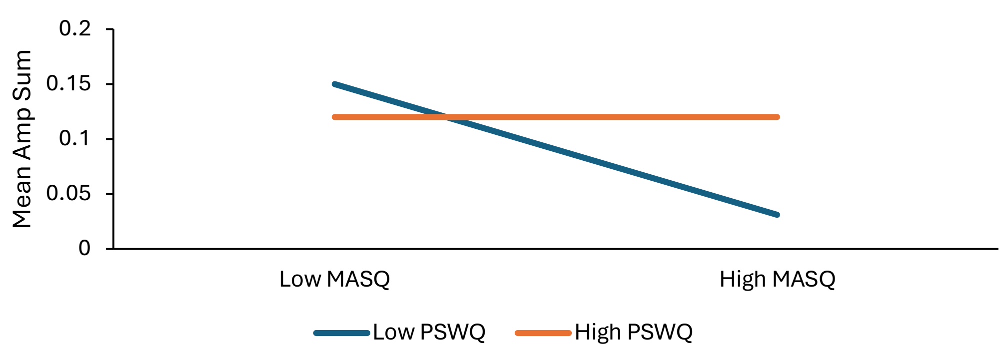
Latency Difference Interaction Between MASQ and PSWQ Group Assignment and Task Introduction Conditions



Note. Graph of the three-way interaction between MASQ and PSWQ group assignment and task introduction for the latency component.

Figure 3

Amp Sum Difference Interaction Between MASQ and PSWQ Group Assignment



Note. Graph of the interaction between MASQ and PSWQ group assignment for the amp sum component.

Between Task HRV Differences

A factorial MANOVA was used to determine the effects of several independent measures on each of the HRV metrics captured. Significant main effects were determined to be significant based on task introduction ($F(4, 17)= 0.0071$, $p< 0.001$), MASQ ($F(1, 17)= 0.086$, $p< 0.001$), PSWQ ($F(1, 17)= 0.18$, $p< 0.001$), sex ($F(1, 17)= 0.060$, $p< 0.001$), and work status ($F(1, 655)= 0.89$, $p< 0.001$. A summary of the main effect results can be found in **Table 9**. There were several interaction effects which were explored for each individual GSR metric through follow-up ANOVA analyses to explore these effects for each metric separately.

Follow-up ANOVA for SDNN yielded significant interaction effects between MASQ and participant sex, $p= 0.0059$. The ANOVA for RMSSD ($p= 0.0055$) and PNN50 yielded similar results ($p= 0.0065$) with a main effect of sex ($p=0.0027$) present for PNN50 which was higher for males. The ANOVA for the Low-Frequency (LF) component yielded no significant main effects or interactions. The high frequency (HF) component yielded a significant main effect for PSWQ group assignment (p= 0.0077) and was higher for those above the mean. Interactions for the HF component were found between the MASQ and sex ($p= 6.4E-4$), the MASQ, work, and task introduction ($p= 1.7E-4$), and between sex, work, and task introduction ($p= 0.0050$). The final ANOVA for the very-low frequency (VLF) component yielded a significant main effect for sex ($p= 3.5E-4$) which were higher for males. Analysis of VLF also yielded significant interaction effects for task intro and sex ($p= 6.4E-4$), the MASQ and sex ($p= 1.2E-5$), sex and work (p= 0.0017), task introduction, PSWQ and sex ($p= 4.2E-4$), and between task introduction, MASQ, and work (*p*= 0.0026). Summaries of means and standard deviations for main effects can be found in **Table 9**. **Figure 4** offers a depiction of the interaction between the MASQ and sex for the SDNN component. Graphs of the interaction between these variables and each of the other components were not included due to redundancy as they followed a similar trend. **Figure 5** and **Figure 6** offer a graph of meaningful interactions for each of the other variables. An adjusted p-value of 0.0083 was used to determine significance.

A factorial MANOVA that aimed to add the effects of talk-aloud to the previous model could not be conducted due to lack of statistical power necessary for analysis.

Table 9

Summary of Group Mean Differences for Latency, Amp Sum, and SCR/ISCR Components Based on Independent Measures

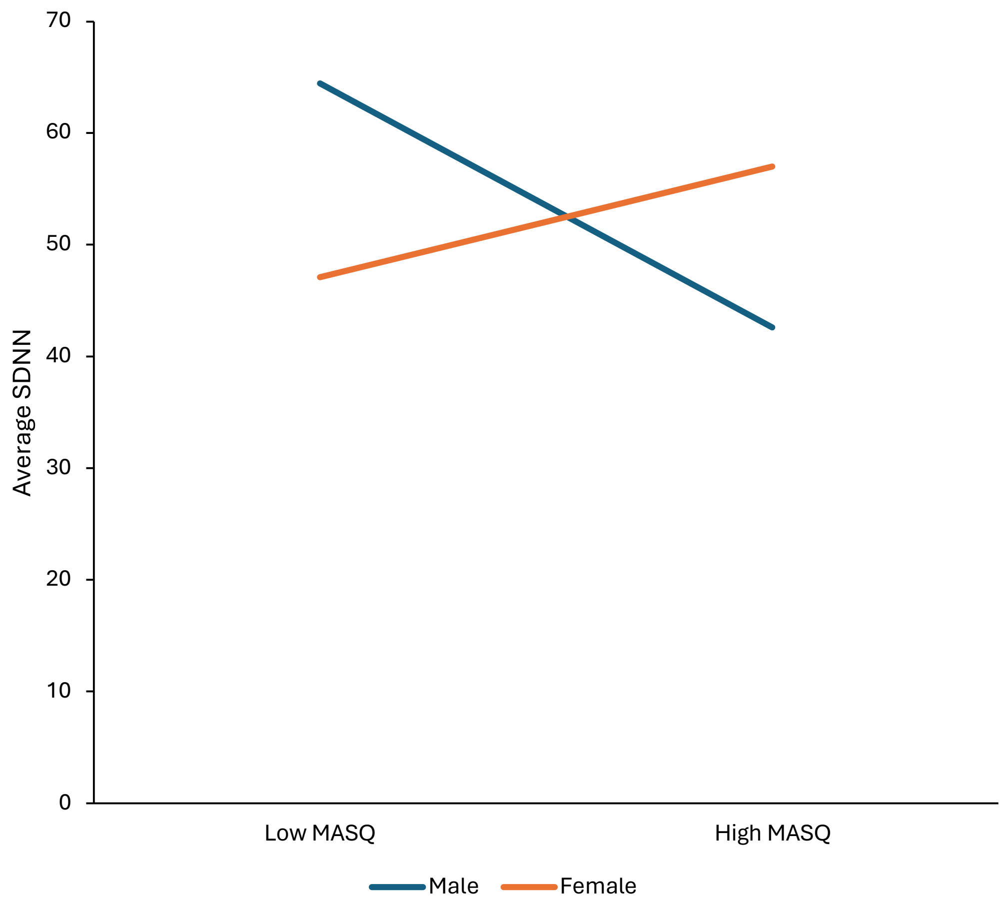
	PNN50		HF		VLF	
Statistic	***M***	***SD***	***M***	***SD***	***M***	***SD***
Low PSWQ	-	-	391.45	315.89	-	-
High PSWQ	-	-	761.59	1234.45	-	-
Male	13.68	7.58	-	-	1288.61	1274.40

Female	8.03	8.75	-	-	850.43	857.32

Note. Means and standard deviations differences for each of the main effects across all components in HRV analysis.

Figure 4

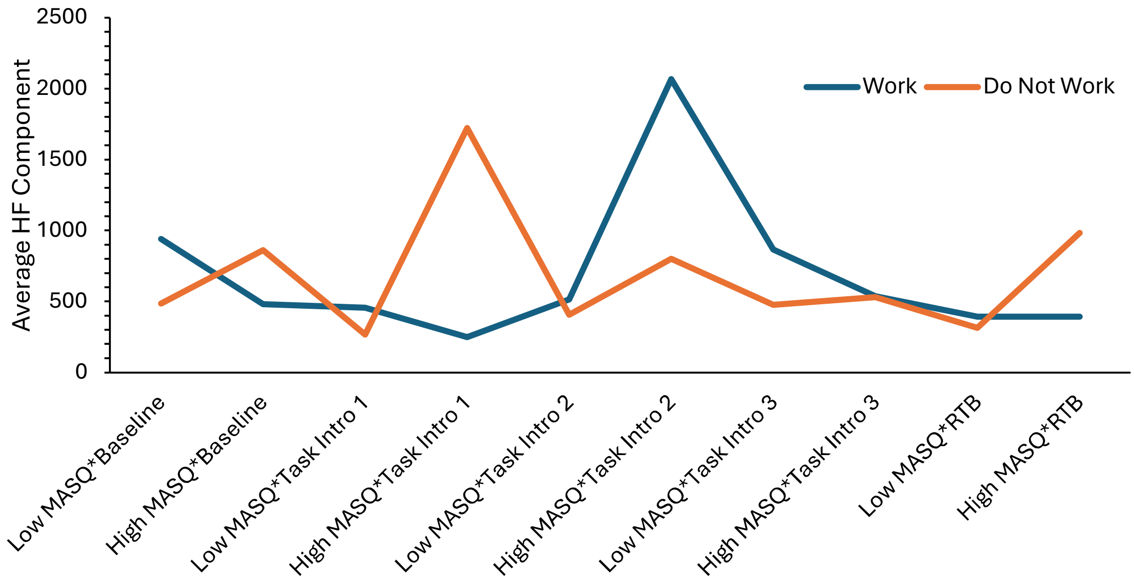
SDNN Component Difference Interaction Between MASQ Group Assignment and Sex



Note. Graph of the interaction between MASQ group assignment and participant sex for the SDNN component.

Figure 5

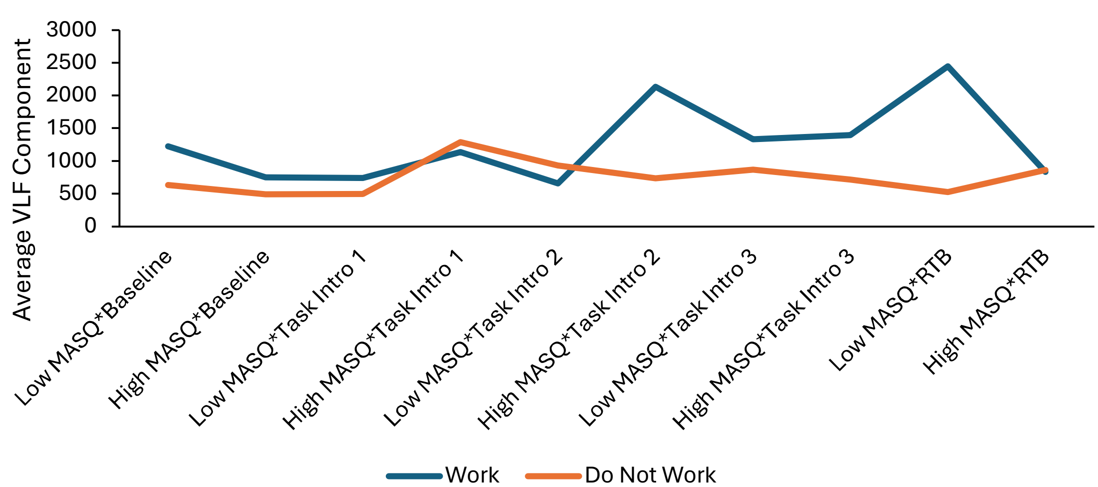
HF Component Difference Interaction Between MASQ Group Assignment, Work Status, and Task Introduction



Note. Graph of the three-way interaction between MASQ, work status, and task introduction for the HF component.

Figure 6

VLF Component Difference Interaction Between MASQ Group Assignment, Work Status, and Task Introduction



Note. Graph of the three-way interaction between MASQ, work status, and task introduction for the VLF component.

Discussion

As for the results of the main effects for the GSR, these indicate mean differences dependent on the indices being investigated. A consistent main effect across amp sum, ISCR, and phasic components indicated that there were activation differences for those that scored below the mean on the MASQ. Considering research has found that those higher in anxious arousal tend to have less intense reactions in terms of brain activity (Engels et al., 2007), it is to be expected that this finding is corroborated in GSR metrics. This result thus is in line with the neurovisceral integration hypothesis in that similar reactions have been found at the level of the brain and in measures of autonomic arousal (Thayer et al., 2012). Of note are differences for those grouped based on PSWQ score either side of the mean. The only component which showed a significant difference based on the groupings used was for the phasic component. For this component those with higher scores on the PSWQ showed greater reactions than those with lower scores. This is an interesting finding as research has been done that supports greater activation in the brain for those who score higher on the PSWQ, however this is in comparison to those in anxious arousal groups based on the MASQ (Moser et al., 2013). It is still interesting especially given that the phasic component is a measure of maximum activation, signifying potential sympathetic arousal differences in line with prior research. PSWQ and MASQ interactions were found for only two measures of GSR. These included latency and amp sum metrics which both showcased differences in line with previous research. Those high in MASQ and low in PSWQ showcased decreased latencies while the opposite was true of those high in PSWQ and low in MASQ. Similar results were found for the amp sum metric. These results also fall in line with research that investigated activation differences (Engels et al., 2007; Moser et al., 2013). To corroborate these GSR findings further is that the high frequency (HF) component of HRV was also increased in those in the high PSWQ group. The HF component has been linked to increased PSNS cardiac activity meant to signify adaptation of the individual to changing environmental demands (Thayer & Lane, 2000). This result points to those high in PSWQ show increased PSNS activity to aid in inhibiting SNS activity. It remains unclear whether the HF component is simply a reflection of PSNS activity rather than a marker of better adaptation to changing environments. Given that those who are higher in anxiety tend to show deficits in their ability to respond to changing environmental demands (Thayer & Lane, 2000), it could be that the PSNS is having to work harder to combat the changes in autonomic arousal from the SNS contributing to the result. The implications of this for conceptualizing pathological worry are such that it is not a result of decreased activity of the PSNS that results in overaction of the SNS leading to worry but rather the degree to which strategies meant to aid in curbing the increased SNS activation that are causal in determining this as an outcome. Measures of performance could help to further this conclusion (Eysenck, 1985; Eysenck, 1992; Mueller et al., 1992); however, performance-related differences were not found for GSR metrics and were not possible due to lack of statistical power for HRV metrics.

Across measures, exercise trended toward increased activation for those that exercised in the moderate to high ranges. This was met with an opposite trend for latency as those that exercised in the moderate to low range had increased response latency. As of yet there are few studies which have incorporated exercise as an independent measure in analysis, making conclusions as to the effects of this on the measures found to be difficult to draw. Latency results could be as expected, as those that exercise more tend to perform better in terms of reaction time (Brisswalter et al., 1997). Given the better reaction time it is posited that this results from a faster processing of sensory information that can be integrated into a response that fits the situation (Ribeiro et al., 2016). As for Amp Sum, ISCR, and phasic components, all which measure activation based on the intensity of the waves captured in data analysis, greater intensities like that found for the moderate to high exercise ranges, could reflect the bodies' ability to better respond appropriately to changes in the environment. Given those that exercise have increased HRV reflecting an appropriate balance between SNS and PSNS activity (Routledge et al., 2010), this could mean that the body is better able to activate aspects of the SNS when placed under certain environmental conditions which is reflected in the increased GSR activation. However, this conclusion is not fully supported by the analyses of this study as HRV measures did not show differences for those that exercised more. This could however be due to performance having impacts on decreasing HRV more broadly (Alfonso & Capdevila, 2022).

Other less pertinent findings were found within the data. Work based differences when interacting with the MASQ were consistent across GSR metrics. Amp sum, ISCR, and phasic component measures all indicated a trend signifying decreases for those that worked only if they scored higher on the MASQ. There were no differences between work status if participants did not work. This is interesting as the results point to work being a mechanism that drives the relationship. It could be that individuals that work naturally tend to respond less strongly to stimuli in the environment through work acting as a basis for increasing their arousal threshold. Task based differences based on MASQ group assignment and work status were also found for HF and VLF components which may aid in furthering this conclusion. Namely, the HF component increased for those that worked on task introduction 2 whereas those that did not work showed increases for task introduction 1. For each group, subsequent task introductions did not result in similar activation as measured by HF. For ECG measures specifically, there was a relationship across metrics for MASQ group assignment and participant sex. Each of these trended toward females having increases in HRV when they were higher in MASQ while males trended toward having decreases in HRV when they were higher in MASQ. In addition, males had greater HRV when low on the MASQ when compared to females. This points to a possible societal bias in the conceptualization of anxiety and coping skills employed for men versus women. Women tend to deal with problems by internalizing while men tend to externalize their behavior (Smith et al., 2018). Given that the MASQ is indicative of arousal characteristics, men who score higher on this metric may struggle with adaptively coordinating behavior within societal norms that lead to the differences seen. In other words, men face societal pressure to handle problems in particular ways that lead to ANS activity differences as they struggle internally with inhibiting inappropriate behavior in a situational context.

Overall, the study had limitations that affected the degree to which the conclusions can be interpreted. Much of this pertains to sampling procedures which would have aided in the generalization of results to neurophysiological findings. Multiple studies have been conducted which have incorporated thresholds that must be met to ensure proper grouping of participants based on MASQ and PSWQ scores (Engels et al., 2007; Heller et. al, 1997; Nitschke et al., 1999). This involved recruitment of participants that fell above the 80th percentile mark on either survey being classified as predominantly arousal or apprehensive type respectively while additionally being below the 50th percentile for the other survey. This, unfortunately, was not possible as only 37.5% of individuals completed both the survey and in-person portions of the experiment, meaning that those that did not meet this criterion could not be exclusively recruited. Beyond this, there were issues with differences in methods of capturing GSR and ECG measures. GSR measures were done on a trial-by-trial basis, while ECG measures were conducted as an average over the entire interval of recording. This leads to decreased validity of the connections between measures as ECG measures done in a similar fashion to that of GSR may have more accurately represented ANS fluctuations over the interval. In other words, ECG measures were not as specific to differences found between those of GSR which decreases their ability to be generalized in the same fashion. Trial by trial differences of ECG then point to better moment to moment fluctuations which more accurately reflect changes in ANS fluctuation directly related to self-regulation. The issue with this extends to the ability to detect significant results due to lack of statistical power. With analysis being done over the course of the interval there exists less data that would allow for sufficient detection of differences. This affects the magnitude of detecting true fluctuations in HRV metrics which are more in line with the purpose of the study.

In conclusion only some of the hypotheses of the study are supported by the results. Findings pertaining to differences in GSR metrics for the MASQ showcase findings in line with already established literature on activation differences for those that score higher on the measure. These aid in the conclusion that there exists a difference in metrics for those high in anxious arousal (Engels et al., 2007). The HF component showcased a difference based on PSWQ group assignment, signifying a differential role of PSNS activation in aiding these individuals in inhibiting arousal from environmental stimuli. Additionally, latency and amp sum metrics showcase interactions with the PSWQ. What the interaction allows for is a direct comparison between groups high on either anxious arousal or apprehension and low on the other measure. Both the latency and amp sum metrics showcased differences that were in line with neurophysiological findings signifying differential activation between groups. This could signify that that only certain components allow for detection of differences. However, it is unlikely that such a result would not result in some differential findings across HRV measures like that of this study pointing to limitations. These mainly have to do with the differences in analysis methods used for GSR and ECG measures but also extend to true differences that could be better explored with more adequate group assignment.

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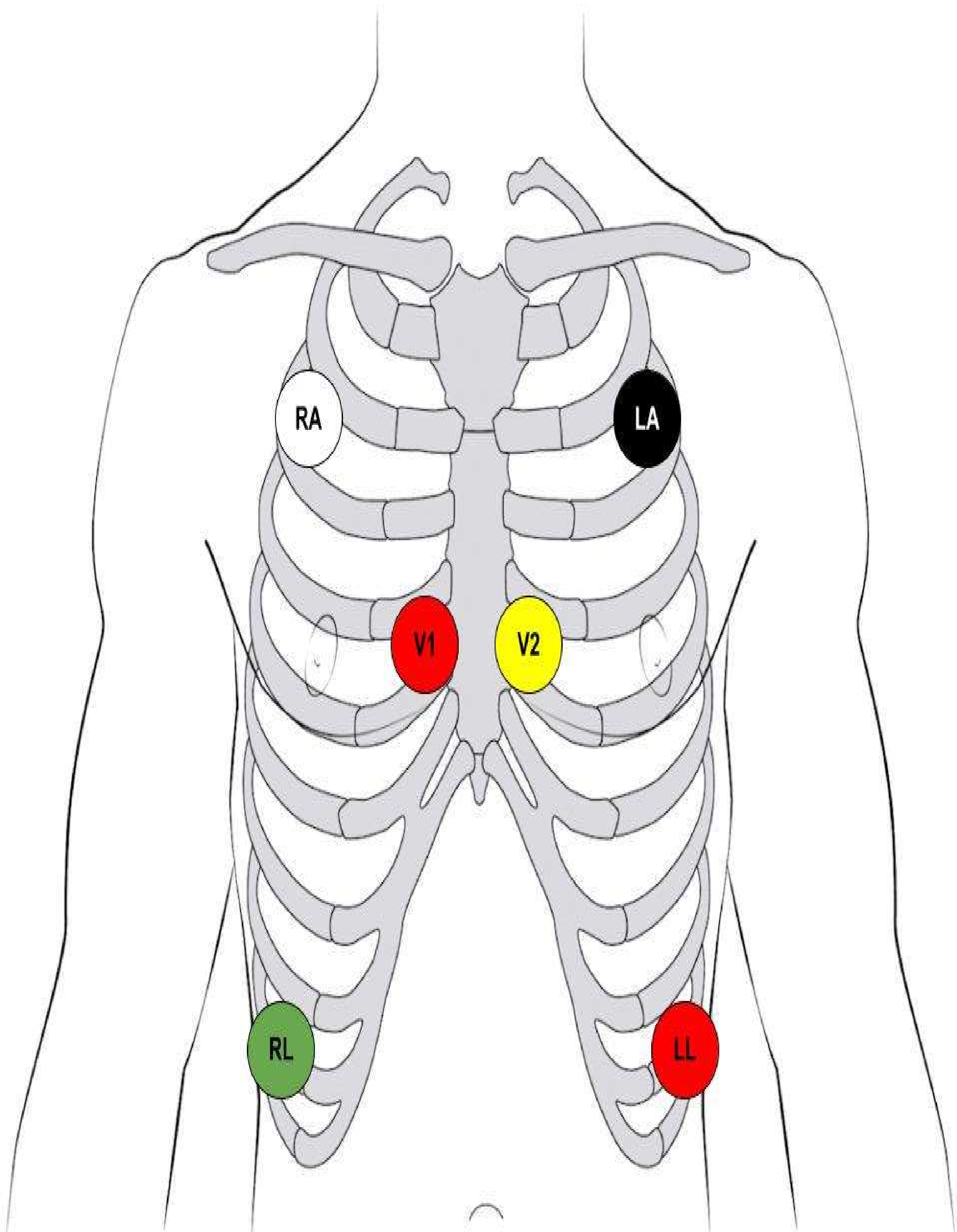
Appendix I

Diagram of ECG lead placement used for the capturing of ECG data.



Appendix II

Example sheet of positive affirmation statements provided for task introduction 3.

"I am doing well on this task"

"I feel that I can get these questions correct"

"This task is not all that difficult"

"I believe in myself"

"I am capable of so much"

"I am doing my best"

"I am making the right choices"

"I trust my decisions"

Appendix III

Example of screen displayed to participants for each trail of the letter transformation task.