Investigating the Impact of the Implicit Association Test on Stress by Measuring Heart Rate Variability and the Moderating Role of Neuroticism

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PSB3E-BT15: Bachelor Thesis

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April, 2024

Acknowledgements

No content generated by AI technologies has been presented as my own work.

I acknowledge the use of ChatGPT (openai.com) to generate materials for background research and self-study in the drafting of this assessment.

I acknowledge the use of ChatGPT (openai.com) to generate materials that are included in my work in a modified form.

Abstract

This study examined the physiological stress response elicited by participation in the Implicit Association Test (IAT). Both a relatedness of physiological stress measured with heart rate variability (HRV) and perceived stress were investigated. Thirty-three participants took part in the IAT after filling in the Big-Five Inventory and a Gender questionnaire, while their HRV was monitored. The results revealed nonsignificant differences in HRV between congruent and incongruent trials of the IAT. An additional assumption of a predisposition to perceived stress in individuals scoring high on Neuroticism was expected for this study. On the contrary, Neuroticism also did not seem to predict HRV in the participants. Nonsignificant Pearson-correlations between HRV measurements and SAM-scores challenged assumptions of a link between physiological stress and perceived stress. With limited studies in this field, future research should focus on improving the diversity of the sample and comparing different manipulations. Unless this study did not find significant results, it underscores the importance of awareness of stress inducements during psychological testing.

Key words: implicit association test, physiological stress, heart rate variability, Big-Five inventory, neuroticism, perceived stress, self-assessment manikin

Investigating the Impact of the Implicit Association Test on Stress by Measuring Heart Rate Variability the a Moderating Role of Neuroticism

The role of stress in health-related outcomes spans various disciplines, all aiming to unravel the connection between an individual's characteristics and their susceptibility to stress and related psychopathology. This topic traces back to ancient Greek times, when one was already assuming a mind-body connection, a concept later expanded by Freudian's psychological theories in which he drew attention to the interplay between physiological arousal and mental illness (Grant, 2011). As research progressed in subsequent periods, increased focus was raised on a definition of stress, which tends to be not just a subjective experience. Walter Bradford Cannon was the first person in 1915 who described a physiological stress response of the body and named it 'Fight-or-flight' response. He described is as a physiological reaction of the body as a survival mechanism that occurs in reaction to a stressful or threatening situation. A stressful trigger leads to changes in the hormonal and nervous system to help a person fight the threat off or flee to safety. In the past decades, researchers have been conducting research into the underlying structures, causes and effects of this response (Harvard Health Publishing, 2011). This led to an increased focus on personality traits influencing an individual's susceptibility to stress and related psychological problems (Grant, 2011). The Five-Factor model, a widely evidenced and acknowledged framework of personality traits, was established to VERKLAREN most variation in personality traits with five distinct scales (Costa & McCrae, 1994). Particularly, individuals with characteristics of Neuroticism tend to be more sensitive to stress and the experience of negative emotions than other individuals. Since Neuroticism is one of the most extensively researched personality traits and due to its role in various personality disorders and psychopathology, research on the impact of stressful conditions could contribute to the current

knowledge about the origin of the negative feelings and stress in individuals with high levels of Neuroticism (Barlow et al., 2014; Zauta et al., 2005).

The Implicit Association Test (Greenwald et al., 1998) is a test that relies on implicit associations between two contrasting concepts under the assumption that the subject categorises familiar or close concepts more easily and quickly than unfamiliar concepts (Nosek et al., 2005). Usually, concepts that elicit biases regarding other ethical races are used to measure implicit biases towards other races. If participants become conscious of their biases, it can result in negative feelings such as stress. Individuals with a higher predisposition to stress, for instance, individuals with high levels of Neuroticism, might perceive higher levels of stress and negative emotions than other individuals as a result of participating in the test. Research on the impact of stressful conditions could contribute to our current knowledge about the origin of the negative feelings and stress in individuals with high levels of Neuroticism (Oswald et al., 2013). Earlier research provided evidence that individuals with higher levels of Neuroticism show more negative affect in response to controlled and naturalistic stressors (Zauta et al., 2005). Additionally, individuals with higher levels of Neuroticism are also more likely to report the experience of negative affect as distressing (Barlow et al., 2014). The question arises if a stressful situation leads to a negative experience, and moreover, if this can be physiologically identified. In this research, it is aimed to find the relationship between stress and performance on the IAT, with an additional focus on how an individual's level of Neuroticism moderates this effect. Despite the frequent use of the IAT, there is hardly any research on the psychological consequences of participation in the IAT on the stress levels of an individual with a personality characterised by Neuroticism traits. Current findings mainly focused on the relationship between Neuroticism and perceived stress, which is associated with underlying physiological mechanisms such as heart rate variability (HRV) ((Di Simplicio et al., 2012; Moeller et al.,

2010). No research has been done providing the same research goals or analysing the combination of variables used in this design

Literature review

Neuroticism

Neuroticism is part of the Five Factor Model, explaining the five higher-order domains of personality traits (McCrae & Costa, 1999). It is often referred to as negative affect or negative emotionality as it reflects an individual's experience of negative affect, including anger, anxiety, irritability, depression, and emotional instability (Tackett & Lahey, 2017). The Big Five Inventory (BFI) is a scale consisting of 44 items to measure the five universally recognized domains of personality: Extraversion, Openness, Conscientiousness, Neuroticism, and Agreeableness. The scale with 44 items has a high reliability ($\alpha = \leq .55 \leq .87$ for the Dutch version and $\alpha = \leq .44 \leq .76$ for German version). For the subscale Neuroticism the reliability is even higher ($\alpha = .86$ for Dutch scale and $\alpha = .66$ for the German scale) (Denissen, et al., 2008; Rammstedt & Danner, 2017; Hahn, 2012). Neuroticism is one of the most researched and empirically proven personality traits and its substantial heritability, temporal stability, and cultural ubiquity are underpinned by an extensive amount of research (Widiger & Oltmanns, 2017). Neuroticism has been studied the most due to its large impact on health, work performance, and relationships (Lahey, 2009). There is evidence supporting the consistent and robust associations of neuroticism with various internalising mental disorders and personality disorders (Clark & Watson, 1991). Additionally, individuals scoring high on neuroticism are associated with reporting substantively more subjective and objective complaints about their physical health (Lahey, 2009). With a predisposition to experience negative affect states, Neuroticism is also associated with a higher risk for anxiety and depression, both include stress-related symptoms (Clark, L. A., & Watson, D., 1991).

Stress

The search for a definition of stress has always been a challenge among researchers. According to the World Health Organization (2023), stress can be defined as "A state of worry or mental tension caused by a difficult situation. Stress is a natural human response that prompts us to address challenges and threats in our lives". Stress is a very subjective state of well-being, as every individual perceives it uniquely. Perceived stress refers to the extent to which an individual evaluates situations as being stressful (Cohen et al., 1983). Research by Tackett and Lahey (2015) and Yang and others (2022) supported the relationship between perceived stress and Neuroticism. The fear of COVID was significantly mediated by the levels of Neuroticism of an individual, serving as supporting evidence of high levels of Neuroticism as being a good predictor of perceived stress. An explanation is that higher levels of Neuroticism in individuals result in proneness to worry, independent of the availability of threats, which makes individuals vulnerable to stress (McCrae, 1990). Neuroticism does not only have a subjective influence on perceived stress but also affects objective stress symptoms such as physiological stress. At present, a universally recognized measurement of stress does not exist, but researchers are trying to detect biomarkers that are useful as a stress index (Castaldo, 2019; Janssens, 2016) Most studies focus on examining biomarkers such as heart rate variability (HRV) that respond to environmental and physiological stressors (Kim et al., 2018).

Heart rate variability

This research makes use of HRV as a potential indicator of stress perceived by participants induced by the IAT. HRV refers to the fluctuation of the time intervals between consecutive heartbeats. In research, it is used as a marker for assessing the relationship between the autonomic nervous system and cardiovascular health (Berntson, 1995). The autonomic

nervous system is part of the peripheral nervous system that regulates involuntary physiological processes. The parasympathetic nervous system (PNS) and sympathetic nervous system (SNS) are part of the autonomic nervous system and these pathways are affected when a person experiences psychological stress (Sternini, 1997). The SNS is associated with the 'fight or flight' response as a response to stress, resulting in physiological changes preparing the body for action. The PNS physiologically alleviates stress responses by inhibiting homeostatic processes in the body. Homeostatic processes are internal regulatory processes that organisms use to maintain a stable internal environment, for instance, a balanced blood pressure, body temperature, and heart rate. When the body is in a resting state and the PNS is active, this is associated with an increased HRV. Stress disturbs the homeostatic processes and results in prioritising external stimuli over internal needs, associated with decreased HRV (Rotenberg & McGrath, 2016). HRV serves as a valuable tool to measure both SNS and PNS activity, providing insights into the body's ability to manage stress (Koskinen et al., 2009) (Berntson et al., 1997). Along with this line of reasoning, research from Castaldo and others (2019) established a significant correlation between HRV and stress. By using 23 HRV measurement features they found substantial changes in 18 of them when participants were put into stress conditions. The HRV measurements demonstrated consistent results across multiple time scales, and with an accuracy of 94% of stress detection by measuring HRV, this research provides evidence for the relationship between stress detection and HRV. However, in a study by Janssens et al. (2016), the results for the relatedness of HRV to perceived stress are quite contradictory. In this study, the relationship between perceived stress levels in 715 adolescents during and after taking the Groningen Social Stress Test was investigated. They found a non-significant relationship between HRV and perceived stress levels during as well as after the test. Conversely, an individual's perceived stress was significantly associated with functional somatic symptoms, which means that perceived stress, even though not visible in the HRV,

may have an impact on an individual's health. In the current experiment, the assumption of a relationship between HRV and perceived stress is checked by asking the participants to fill in the Self-Assessment Mannikin (SAM) (Lang, 1980; Hodes et al., 1985) during and after participation to the IAT. The SAM is a non-verbal pictorial assessment technique that measures the participant's affectional state on three scales: Arousal, Dominance and Valence. The SAM scales have significant, very strong relationships ranging from .79 to .99 with ratings of affectionate state obtained through differential methods. The SAM is a useful instrument for measuring mood states across cultures and different age groups due to the use of pictograms. During this study, the SAM is used to get an indication of the level of stress that is experienced by the participant and whether it is consistent with their physiological stress response, measured with HRV.

Neuroticism and HRV

Individuals with higher levels of Neuroticism are expected to show impaired regulation of the SNS when confronted with negative emotional challenges, according to Di Simplicio (2012). Research from Ode and others (2010) found no significant direct relationship between levels of Neuroticism and HRV. Despite these contradicting outcomes, the study emphasised the existence of an interaction between low HRV and Neuroticism, which leads to negative daily outcomes such as stress reactivity, negative emotion, cognitive failure and impulsive behaviour. In another study, participants were assigned to a group based on their level of Neuroticism and had to participate in multiple emotion-regulation tasks to investigate whether differences in HRV would determine emotion-regulation patterns (Di Simplicio et al., 2012). No significant differences in emotion-regulation styles between the groups were found, but they did find significant differences in HRV levels. Low-Neuroticism individuals showed significantly higher HRV levels during emotional down-regulation, compared to maintenance of emotions. This indicates enhanced parasympathetic flexibility. Subjects with high-

Neuroticism did not show a significant difference in HRV between the two conditions, suggesting reduced parasympathetic flexibility during the cognitive regulation of emotions. In other words, Neuroticism is associated with limitations in the flexibility of the autonomic nervous system, and thus, with managing stressful situations (Di Simplicio et al., 2012). On the contrary, in another study, where they anticipated a relationship between Neuroticism and perceived stress, as well as between physiological stress reactivity and perceived stress, the physiological stress reactivity emerged as a moderating factor in the relationship between Neuroticism and perceived stress. Individuals with low physiological stress reactivity exhibited a non-significant relationship between Neuroticism and perceived stress. Those with higher levels of Neuroticism appear to cope better with physiological stress responses, perhaps because they perceive them more frequently. Consequently, they adapt physiologically to stress, yet still perceive it more intensely than individuals without elevated Neuroticism (Kaplan et al., 2022). These findings could provide further explanation for the low HRV observed in individuals with higher levels of Neuroticism as they show lower physiological responses to stressful situations. In this research, the IAT is used as a congruent task to recreate a stressful situation, which is expected to result in the same conclusions about increased stress levels visible in HRV of individuals with higher levels of Neuroticism.

The IAT

The IAT rests on the assumption that it is supposed to be easier to make a behavioural response to a concept that is similar to the original representation than to one that is weakly associated with the representation. The IAT is designed to measure associations without participants having conscious biases during the performance. Participant's consciousness of their responses is limited as they are instructed to respond quickly, which limits their time to control their responses (Nosek et al., 2005). Earlier studies provided evidence for the IAT's sensitivity to changes in acute stress. Higher levels of anxiety seemed to be associated with

induced task difficulty (Sato & Kawahara, 2012). On the other hand, being conscious of racial biases provoked by the IAT, is also associated with changes in HRV, according to Di Palma and others (2019). They found significant changes in HRV in participants who had to judge the pain of in- and outgroup members during different IAT trials. With this very unique research design without replications and a small sample of 48 participants, results have to be carefully considered before generalising over a bigger population. Performance on the IAT and its relationship to HRV and Neuroticism is not compared that often yet, though, the underlying structures such as executive functioning are (Johnson et al., 2012). According to research from Klauer and others (2010), an individual's performance on the IAT is strongly related to functions such as executive control, switching abilities, and working memory. Hansen and others (2009) replicated a prior study conducted by Hansen and others (2003), wherein the relationship between HRV levels and performance on cognitive tasks related to executive functioning was examined. Firstly, they found a significant relationship between low HRV and Neuroticism. Secondly, their results reveal that participants with low HRV, associated with higher levels of Neuroticism, perform better on cognitive tasks in stressful situations compared to normal situations. Low HRV is related to less flexibility to adapt to stressful environments, which results in experiencing stress. The performance of individuals with low HRV is argued to be facilitated by demanding attentional resources and improved attention to cognitive tasks due to the threatening condition. This reasoning is in line with results from Porges and Raskin (1969), who showed that HRV is a useful index for executive functioning and that HRV is significantly reduced during cognitive tests. Thus, individuals with lower HRV are quicker in performing executive tasks, also important for performance on the IAT. At this moment, there has not been any research that has looked at the influence of IAT on the physiological and perceived stress of persons with higher levels of Neuroticism. Moeller, Robinson and Bresin (2010) designed similar research in which they

provided evidence that the interplay between Neuroticism and implicit cognitive associations significantly influences behaviour in a way that leads to stress outcomes such as stress eating. High levels of both Neuroticism and stress-aggression associations were even associated with high levels of aggressive behaviour. This study implies a relationship between Neuroticism and implicit associations, which results in stress outcomes and aggressive behaviour. By performing the IAT we can recreate the environment of an individual having implicit associations. In the case of this experiment, an experimental design is used in which participants first have to categorise the Dutch or German words and names, depending on the participant's nationality. Thereafter, in a congruent task Dutch or German names have to be categorised as positive and Moroccan names as negative. In the last trial, the words and names get mixed and participants have to categorise negative words and Moroccan names as good and positive words and Dutch names as wrong. The incongruent trial is expected to induce stress to the participant, as one gets conscious of preferring the ingroup over the outgroup. The question arises if HRV can clarify the level of stress a participant is experiencing while performing on the congruent and, mainly, on the incongruent trial of the IAT. And lastly, if HRV is a reliable indicator to use to measure an individual's perceived stress level. This leads to the following hypotheses:

Hypothesis 1: Does the performance on the congruent and incongruent task of the IAT cause a physiological stress response to participants that is measurable by the HRV?

Hypothesis 2: Does an individual's level of Neuroticism moderate the relationship between induced stress by the IAT, measured with HRV, and performance?

Met opmerkingen [1]: Nog even naar kijken

Hypothesis 3: Is there a relationship between stress levels measured by the HRV and perceived stress levels for individuals with higher levels of Neuroticism?

Methods

Participants

A total of 49 adolescents (24 females, 25 males) participated in this study. 18 of the participants were Dutch-speaking first year psychology students and 31 were German-speaking first year psychology students, acquired through the SONA research pool of the University of Groningen. The SONA pool consists of first-year students who are required to participate in psychological research to earn credits, with no additional incentives provided for their involvement. The students freely choose which studies they apply for from the available pool, and all participants agreed to take part in this study with informed consent.

Materials and Apparatus

The apparatus consisted of two experimental rooms, one room for the experimenters containing two computers to view the test results of the participants. A separate room, containing one computer, is used by the participant during the experiment. A pen is provided to fill in the informed consent before participating in the experiment. The Polar H10 Heart Rate Sensor and a heart rate band are used to measure heart rate variability during the experiment. The measurements of the Polar H10 were viewed in an electrocardiogram (ECG). During the experiment, the participant used a button box with a green and a red button corresponding to the words of the IAT tasks.

During the entire experiment OpenSesame version 4.0.13 was used to design and run the questionnaires and the IAT tasks. The Big Five Inventory (BFI) (John, et al., 1991) was used as a self-report inventory to measure five of the universally recognized domains of personality: Extraversion, Openness, Conscientiousness, Neuroticism, and Agreeableness. The scale consists of 44 items constructed to efficiently test the domains of the Big Five without differentiating them into individual subsets. The BFI items are brief and simple by

avoiding complex and adversative structures. Participants rate the questions on a five-point-scale ranging from 1 (strongly disagree) to 5 (strongly agree). The scores of participants on the domains were computed as the participant's mean item response. The BFI has a version for Dutch-speaking participants and a for German-speaking participants. The personality questionnaire consisted of three open questions in which the participant answered to which gender they identify. The questions were established by the researchers (Appendix A). Lastly, the Self-Assessment Manikin (SAM) (Bradley & Lang, 1994) was used to obtain participant's affective state before, during, and after the performance on the IAT. The SAM is a non-verbal assessment technique using pictograms to directly assess feelings of pleasure, arousal, and dominance experienced by the participant. Earlier research provided evidence of positive and strong correlations between anxious states and scores on the SAM ($R(1176) = .860$, $p < .001$) (Alberto & Paul, 2016). The IAT version made use of, consisted of a Dutch version and a German version. The Dutch version included common Dutch names. The German version included the most common German names (Appendix A).

Research Design and Procedure

Each participant followed the same procedure while participating in the experiment. The experiment took place in the basement of the Heymans building at the University of Groningen. Before the experiments started, participants were told that personal details of the participants were treated confidentially, and it was accentuated that participation is voluntary and that they can stop at any time. After the participants read the instructions and agreed to participate in this research, the informed consent is signed. Subsequently, the researcher explains that the heart rate sensor has to be applied on the skin of the middle part of the chest with the band underneath the armpits. Thereafter, the researcher connected the heart rate sensor to the lab recorder to create an ECG on the computer. When the participant's heart rate was visible and was ready, the researcher first started the BFI. After completing this

questionnaire, the experimenter starts the gender questionnaire. After finishing both questionnaires, the experimenter starts the IAT. The IAT is used to manipulate the heart rate variability by creating a stress response. During the IAT, the participant has to use the button box to categorise the Dutch or German words and names, depending on their origin, during different trials alternated by affectionate mood state measurements with the SAM. Three rows of each seven pictograms were shown, each row representing a different affectionate state. The SAM is filled in by choosing a pictogram that reflected the participant's state of mood for a specific scale. An alarming sound was heard when the participant categorises words in the wrong category, which could also result in an extra stress response. After the tasks were completed, the participant was asked to take off the heart rate belt and the goal of the experiment was explained by the experimenter in the debriefing. It was emphasised that the ECG data was going to be used to find any relationship with stress and not to draw any medical conclusions. Additionally, it was double-checked if participants left the experiment room without any negative feelings or stress.

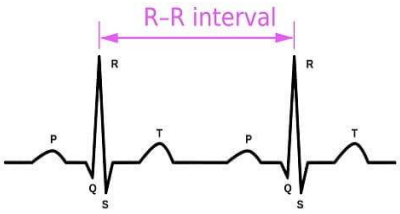
Of the 49 participants who participated in this study, 16 were excluded by reason of unusable data. This was primarily the result of equipment malfunctions, particularly in the heart rate band, or noise in the ECG trace that could not be eliminated.

Measures

During the experiment, an ECG was made to monitor and measure participant's heart rate and heart rate variability. The Polar H10 heart rate sensor is a reliable measure of the heart rate that was translated to an ECG in Labrecorder (Schaffarczyk, et al., 2022). Figure 1 shows an example of the amplitudes of an ECG. The data from the ECG used for analysis

Figure 1

RR-interval displayed in an ECG



during this study were mainly the IBIs (inter-beat interval), which is the time in milliseconds between two R-tops, or the RR-interval. The R-tops (Figure 1) are the peak of electrical impulses generated when the heart ventricles contract. HRV was calculated by taking the root mean square of successive differences of IBIs, divided by the mean IBI in sec, resulting in the corrected root mean square of successive differences (cRMSSD) (Oxford Medical Education, 2016).

Results

Table 1 gives an overview of the descriptive statistics of the heart rate data of the participants from the sample (n = 33), as measured by the Polar band, used in the analysis. The Table shows the mean values of the cRMSSD and reaction times in both the congruent and incongruent tasks. On average, the mean values of the cRMSSD during the incongruent trial is higher than for the other trials. Table 2 describes the scores on the BFI of all domains with a particular focus on Neuroticism in this research.

Table 1

Descriptive Statistics of Heart Rate Measurements During the Experiment and Neuroticism Outcomes.

Variable	Mean	Standard Deviation	Minimum	Maximum
cRMSSD BFI (ms)	53.911	33.492	12.160	150.518
cRMSSD Congruent Trial (ms)	58.077	30.366	12.047	157.244
cRMSSD Incongruent Trial (ms)	63.019	30.887	14.034	156.545
Response time correct congruent trial (ms)	810.905	338.309	626.906	2846.382
Response time correct incongruent trial (ms)	944.231	288.095	620.871	2210.893

Table 2

Descriptive Statistics of Scores on BFI of all Domains

Variable	Mean	Standard deviation	Minimum	Maximum
Neuroticism	25.788	5.915	14.000	39.000
Agreeableness	36.424	3.921	27.000	43.000
Extraversion	25.758	7.159	13.000	40.000
Openness	35.303	5.693	23.000	46.000
Conscientiousness	32.121	5.878	19.000	41.000

Table 3

Shapiro-Wilk Values from the cRMSSD during Questionnaires and Trials of the IAT

Variable	Shapiro-Wilk	*p*-value
cRMSSD BFI	.865	<.001
cRMSSD Words	.825	<.001
cRMSSD Names	.811	<.001
cRMSSD Congruent Trial	.875	.001
cRMSSD Incongruent Trial	.900	.005
Neuroticism	.979	.767

Table 3 shows that the mean scores on the Neuroticism scale of the BFI are normally distributed, as expected. On the contrary, the assumptions for a normal distribution of the cRMSSD data are validated. Therefore, it is chosen to perform non-parametric tests to statistically analyse the data. A Wilcoxon signed-rank test is used to determine the differences between the mean cRMSSD of the participants in the congruent versus incongruent trial.

There was found no significant difference in cRMSSD between the congruent and incongruent trial, $z(1.921) = 0.055$, $p = .06$, and this accounted the same for the comparison of names task and the incongruent trial, $z(1.599) = 0.113$, $p < .05$. A significant difference was found by exploring the difference between the words task and the incongruent task, $z(2.636) = 0.007$, $p < .05$.

A repeated measures ANOVA is used to compare the cRMSSD of all participants during the congruent and incongruent trial. Additionally, participants' level of Neuroticism is added as a covariate to check whether this moderates any effect. The results show no statistically significant effect of Neuroticism on the cRMSSD of participants in the congruent versus incongruent trial ($F(1,1) = 0.022$, $p = .883$. This means that the level of Neuroticism does not have an extra influence on the variety in HRV between the incongruent and the congruent trial.

Additionally, the Pearson correlation between cRMSSD and the SAM results are shown in Table 5 and 6 to estimate whether physiological stress, measured with the ECG, is related to perceived stress. A strong positive correlation between the cRMSSD during the congruent and the cRMSSD during the incongruent task is found, $r(7) = .93$, $p = < .001$. A positive, but weak correlation, is found between cRMSSD during the incongruent task and reported dominance, $r(7) = .36$, $p = .038$.

Table 5

Pearson Correlation Between Neuroticism and cRMSSD During the Congruent trials of the IAT with SAM the Three Scales of the SAM Measuring Perceived Stress.

Variable	SAM scores during congruent trials		
	Arousal	Dominance	Valence
cRMSSD Congruent trial	.20 (.268)	.17 (.340)	-.04 (.810)
Neuroticism	.11 (.530)	-.04 (.807)	<-.05 (.959)

Table 6

Pearson Correlation Between Neuroticism and cRMSSD During the Congruent Trials of the IAT with SAM the Three Scales of the SAM Measuring Perceived Stress.

Variable	SAM scores during Incongruent trials		
	Arousal	Dominance	Valence
cRMSSD Incongruent trial	.22 (.229)	.36 (.038)	.15 (.410)
Neuroticism	.11 (.544)	-.05 (.794)	.09 (.627)

Discussion

The present study aimed to investigate whether participation in the IAT elicits physiological stress, which was assessed by monitoring HRV using a Polar heart rate band. The results show no significant relationships between HRV and any of the trials of the IAT, which means there is not a significant change in HRV while performing on the IAT. To give a more in-depth overview of the results of the experiment, this study was split up into three hypotheses.

To answer whether the performance on the IAT caused a physiological stress response to participants, HRV was measured during participation in the IAT. The IAT was split up into different trials. In the first trials words and names simply had to be categorised as positive or negative. Subsequently, words and names got mixed up in the congruent trial and participants had to categorise them according to the same rules as in the previous trials. In the incongruent trial, the participants were again asked to categorise words and names again, but this time negative words had to be categorised as good and positive words as bad. The same accounted for names, Dutch or German names had to be categorised as negative and Moroccan names as positive. It was expected that participants would feel very uncomfortable and distressed when they became conscious of their bias or preference for their ingroup. In line with the results of a similar research design by Castaldo and others (2019), who established significant correlations between 23 HRV measurements and stress by making use of stress conditions in which they used verbal examinations of students, a physiological stress response visible in changes in the HRV was expected. Notwithstanding the predictions, the HRV did not change significantly in the incongruent task compared to the congruent task. When people become conscious of their preference for categorising their ingroup as positive, and thus, their outgroup as negative, it was expected that people would feel very uncomfortable and distressed. The stress response was predicted to be observable in the HRV, as this is a valid

marker for stress (Castaldo et al., 2019). A clarification for the nonsignificant result is that participants' consciousness of their response is limited, as they are instructed to respond as quickly as possible during the IAT trials. It is noteworthy, though, that the mean reaction times during the incongruent trial were higher than during the congruent trial and all other trials as people tend to categorise their ingroup (Dutch or German names) easier as good than the outgroup (Moroccan names) (Nosek, et al., 2005) In this experiment, the higher reaction time could be explained by the time the participant needed to suppress their bias, but that did not lead to a significant stress response, measurable in HRV.

Furthermore, the participant's level of Neuroticism was measured to seek a relationship with a stress response during the IAT. By filling in the BFI, the participant's level of Neuroticism was determined, and its relatedness to their physiological stress response was examined. Neuroticism is associated with a negative interpretation of a situation and a higher predisposition to stress, and so, higher levels of Neuroticism were expected to result in significantly lower HRV, compared to individuals with lower levels of Neuroticism. The results of this study revealed that the participants show moderate-to-high levels of Neuroticism (Tucaković & Nedeljković, 2023). Moreover, a repeated measures ANOVA has shown that Neuroticism did not significantly change the HRV in any of the trials, nor explains the difference in HRV between individuals. As HRV did not change significantly in the first place while performing on the IAT, the question arises if it can be concluded that Neuroticism is not related to stress. This reasoning is in line with previously done research by Ode and Others (2010), who did not find a significant relationship between Neuroticism and HRV. They emphasised a possible interaction between low HRV and Neuroticism that leads to negative daily outcomes. On the contrary, research from Tackett and Lahey (2015) found supporting evidence for the relationship between Neuroticism and perceived stress during the COVID pandemic. It is noteworthy that stress experienced when participants have to

participate in the IAT could be different from stress experienced when having to deal with a life-threatening virus. Additionally, there might be a difference between perceived stress and physiological stress. This relationship is also explored during this research, with the additional moderating effect of the level of Neuroticism in individuals.

Individuals with higher levels of Neuroticism tend to interpret situations more negatively. Therefore, it was expected that perceived stress in these individuals might be higher compared to their bodily reactions to stress. To differentiate between physiological stress and perceived stress, the experimental design incorporated alternating trials with a questionnaire (SAM), prompting participants to rate their perceived stress levels on three scales: arousal, dominance and valence. First, by looking at the results of Pearson's correlation (Table 5 and 6), the relationship between physiological stress, displayed as cRMSSD, and perceived stress is shown for all the trials. Nearly all correlations are weak and nonsignificant, from which can be concluded that there is no significant evidence for a weak or other relationship between these variables. Nonsignificant results for the relationship between the congruent task and perceived stress were expected, as in this task stress is not meant to be elicited. On the contrary, for the incongruent task, a stronger relationship between perceived stress and cRMSSD was presumed. Just for the Incongruent trial and the dominance scale a significant, but relatively small, correlation has been found. This implies low HRV could be related to reduced feelings of dominance. A lack of understanding of the meaning of the dominance pictogram could be another clarification for the correlation, as participants might misinterpreted the pictogram. The results of this experiment, even though nonsignificant, are consistent with the conclusions of Janssens and others (2016) who did not find a relationship between perceived stress in 715 adolescents and HRV. They did find a significant relationship between perceived stress and functional somatic symptoms, which implies that perceived stress, even though not measurable in HRV, impacts the individual's

health. A substantial amount of research has been done on the relationship between HRV and perceived stress, but most studies have different research designs which makes it hard to make a valid comparison. For instance, studies from Britton and others (2019) and Moreira and others (2021) highlighted the significant relationships between perceived stress and HRV. A remarkable difference with their study design is that they measured perceived stress in a daily-life setting, instead of induced by a stressful test such as the IAT.

Implications

This research has some limitations. To start with the fact that there has never been done any identical research, so, a comparison with previous research is limited to comparing to studies with similar variables. This makes it hard to make a one-by-one comparison. A second theoretical implication is that one of the characteristics of the IAT is participants have limited response time resulting in less ability to be conscious of racial bias (Nosek et al., 2005). The minimal time to respond might limit the stress that is experienced by participants or that is viewable in their HRV.

Secondly, although the nonsignificant results of a relationship between low HRV and Neuroticism were in line with results from previous studies, the research designs and samples differ substantially. In previous research from Ode and others (2010), an interaction between low HRV and Neuroticism, resulting in worse daily life outcomes, is suggested, but this cannot be confirmed with the current analysis as the variables are not identical.

Thirdly, for the relationship between HRV and perceived stress, the previously conducted research reported very diverse results. The main difference between these studies is the way perceived stress is defined. Researchers who did find significant relationships between HRV and perceived stress, mostly measured perceived stress as a state of mood, whilst in this experiment a stress response was elicited by a manipulation. Research designs

that made use of manipulation to create stress found similar results as the current study, which means nonsignificant relationships between HRV and perceived stress.

Lastly, drawing any conclusions about Neuroticism not serving as a moderator in the relationship between HRV and perceived stress caused by the IAT, based on the results of this experiment, is hard. The relationship between the two variables is found to be nonsignificant, and thus, it can be concluded that the IAT does not induce a significant change in HRV but it is not valid to state anything about the moderating role of a participant's level of Neuroticism.

Practical implications

Besides theoretical limitations, this study also had some practical limitations. For instance, the IAT takes up to thirty minutes to complete. Participants had to participate in the same task repeatedly, which could have resulted in tiredness or boredom. Mood changes, filled in the SAM, might be the result of tiredness and boredom instead of perceived stress. Other practical implications are related to the HRV measurements. In most of the cases, the heart rate band was put on correctly, but in some of them, it showed a few errors in the ECG. Lastly, the size of the sample causes the study to have a low power. With 33 participants of whom mostly are first-year psychology students, the participants are likely to have similar traits and interests. This results in a lack of external validity of this study.

Based on the insights gained from this study, researchers in the future should focus more on a more comprehensive and varied sample if they want to know what the effect is on stress caused by the IAT. This results in having a bigger statistical power and could lead to more valid conclusions. In future research, the manipulation could also be changed, and the IAT might be exchanged for another test. In this way, the nonsignificant relationship between physiological stress and perceived stress with Neuroticism as a moderating factor might be better confirmed.

Conclusion

In this study, being conscious of racial bias during psychological testing was expected to lead to changes in HRV and negative feelings such as stress. This research did not lead to any significant results, and thus, no conclusions can be drawn about the relatedness of the IAT and stress. Nevertheless, awareness of potential stress elicited by psychological testing, such as with the IAT, and mainly in people with a heightened risk of feelings of distress, should not be underestimated. With limited literature in this field, there is room for improvement in understanding the interplay between racial bias, psychological testing, and stress responses, thereby highlighting the possibilities for further investigation and exploration in future studies with similar designs.

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Appendix A

Table 7

Dutch and German Words Used in the IAT Congruent and Incongruent Trials

Dutch words		German words	
Positive	**Negative**	**Positive**	**Negative**
Vrolijk	Verdrietig	Frölich	Traurig
Vriendelijk	Boosaardig	Freundlich	Bösartig
Samen	Alleen	Zusammen	Allein
Gezond	Ziekte	Gesund	Krankheit
Open	Gesloten	Offen	Geschlossen
Constructief	Destructief	Konstruktiv	Zerstörerisch
Degelijk	Vies	Solide	Schmutzig
Inventief	Zwak	Erfinderisch	Schwach
Lekker	Banaal	Lecker	Unbedeutend

Table 8

Dutch, German and Moroccan Names Used in the IAT Congruent and Incongruent Trials

Dutch names	**German names**	**Moroccan names**
Daan	Peter	Ahmed
Lucas	Wolfgang	Salma
Anna	Michael	Amina
Bram	Werner	Hassan
Floris	Klaus	Ayoub
Diana	Maria	Adil
Tess	Ursula	Ali
Lars	Monika	Omar
Jan	Petra	Hamza

Appendix B

Gender Questionnaire

Questions Dutch version

1. Welk geslacht is aan jou toegewezen bij de geboorte?
2. Als welke genderidentiteit ben je opgevoed tot en met twaalfjarige leeftijd?
3. Wat is op dit moment jouw genderidentiteit?

Questions German version

1. Mit welchem Geschlecht bist du geboren worden?
2. Mit welcher Geschlechtsidentität bist du bis zum Alter von 12 Jahren aufgewachsen?
3. Mit welchem Geschlecht identifizierst du dich heute?