universität wien

# MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

„Neuroticism, stress and salivary flow rate – what is the influence of threat appraisal?"

verfasst von / submitted by

Marie-Sophie Wiebke, BSc

angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien, 2023 / Vienna, 2023

| | |
|---|---|
| Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet: | UA 066 840 |
| Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet: | Masterstudium Psychologie UG2002 |
| Betreut von / Supervisor: | Univ.- Prof. Dr. Urs Markus Nater |
| Mitbetreut von / Co-Supervisor: | Dr. Jasminka Majdandžić |

**Table of contents**

## Introduction

Over the last centuries our way of living became increasingly fast-paced. This lifestyle is accompanied by various stressful situations, and it is important for individuals to manage stress to find balance in their life. Stress is one of the most critical risk factors for psychological and somatic health problems (Schneiderman et al., 2005), and society has become more aware of the adverse health outcomes associated with prolonged stress. Since the negative effects of stress on health outcomes are enormous, it is crucial to identify risk factors that further facilitate adverse outcomes. Stress, however, is incredibly multi-faceted: its origin and expression are tremendously diverse, leading to individual and situation-specific outcomes. How is it possible, though, that some individuals barely seem to experience stressful encounters while others experience many and the reactions to them are, again, so different? Personality factors play an important role in answering that question. *Neuroticism* (N), along with the prolonged experience of stress, is a commonly known risk factor for developing mental disorders. According to Lahey (2009), N is closely associated with various adverse health outcomes, even when controlling for common health risk factors like sex, or socioeconomic status. For example, twin studies indicate an up to 30 % increased risk of developing a major depression for individuals that express higher N (Lahey, 2009). Findings like these are interesting in stress research because a negative response towards stressful events (which facilitates negative outcomes) increases with higher expression of N (Gunthert et al., 1999; Schneider et al., 2012). This leads to a great public health significance concerning N and demonstrates the urgency for appropriate interventions. However, to reduce or prevent the resulting negative effects, it is necessary to understand which mechanisms amplify this vulnerability of N towards stress (Lahey, 2009). Since stressful encounters can only be changed to a limited extent, one possibility would be to analyze the cognitive evaluations of situations.

## Theoretical background

### Stress

When defining the concept of stress and its origins, it becomes clear that stress is an umbrella term describing various concepts, such as the stress reaction within an organism or the trigger of a response from either within a person or the environment (Brinkmann, 2021). There are three different approaches that, taken together, give a

more coherent perspective on stress. The first approach views stress as a reaction triggered within an organism, the second approach focuses on the stimuli triggering reactions within an organism, and the third combines the two as an interactive relationship between organisms and situations (Brinkmann, 2021). The latter helps understand cognitive processes that shape individual stress responses necessary to understand how personality factors influence this very same (Brinkmann, 2021). It is generally agreed that a *stressor* is a threat or challenge to the normal functioning of an organism. While biological systems are designed to adapt to changes, stress occurs once individual resources are exceeded. This results in a dynamic relationship between stressors and the organisms trying to adapt (Lovallo, 2015). In the following sections, three academically recognized views on stress will be elaborated to gain insight into all facets of the concept of stress.

### *Reaction-oriented view*

Walter B. Cannon proposed an early reaction-orientated concept of stress: he introduced *homeostasis,* which can be described as an inner balance or a tendency of an internal milieu to remain constant (Brinkmann, 2021; McCarty, 2016). According to this concept, the organism strives for inner balance through self-regulating processes. This proposition builds a foundation to investigate any deviations triggered by any threat. Considering that, Cannon postulated the *fight-or-flight response* as an adaptive mechanism to adjust to external threats or challenges by interrupting homeostasis. He described stress as the adaptive physiological and mental reaction of living organisms. The fight-or-flight response triggers a cascade of adaptive responses in the body, e.g., increased blood flow through increased heart rate and dilation of coronary vessels (McCarty, 2016). In his work, Cannon described the sympathetic nervous system's crucial role in remaining in a homeostatic state through the fight-or-flight response (McCarty, 2016) and has thereby outlined one of the main agents in the stress response.

Another scientist who focused on the stress reaction was Hans Selye. He proposed the *General Adaption Syndrome* (G.A.S.) (Selye, 1976). The G.A.S. is a framework for the different phases of a stress reaction that describes a universal defense mechanism which follows a challenge. Thereby stress, for Selye, is a uniform syndrome that protects the organism from harm and triggers necessary processes to provide energy. Selye defined the *alarm reaction*, *stage of resistance* and *stage of exhaustion* as the components of the G.A.S. (Selye, 1976). Selye's view

depicts a universal stress reaction which would be independent of any influential factors. This does not represent the current opinion of a specific, individual stress response that varies and, thereby, is not universally constant (Brinkmann, 2021). Especially the individual stress reactivity, which describes the individual disposition to show a particular stress reaction following a specific situation (Schulz et al., 2005), is relevant for this thesis.

McEwen (1998) later added the concept of *allostasis* (Sterling & Eyer, 1988), which is part of homeostasis. Allostasis is, again, an adaptational process of organisms to gain stability by varying factors of the internal milieu around setpoints (e.g. blood oxygen level) to adjust to environmental/external demands (Sterling & Eyer, 1988). Setpoints define a range or precise point that body functions usually express. For example, the body temperature is generally close to 36 degrees Celsius. However, the temperature increases when fighting off infections. Some systems have setpoints, which are more likely to have values within a narrow range and therefore fit well with the view of homeostasis. Others, however, vary considerably with changing situational demands like the immune system, cardiovascular system, metabolism as well as central nervous system and match the concept of allostasis better (Brinkmann, 2021; McEwen, 1998). Allostasis plays a significant role in daily functioning and is therefore crucial for coping with any demands by increasing or decreasing levels of body functions. It is most important, however, that the activity of processes within the body normalize after a specific time. If not, an *allostatic load* occurs, commonly described as the cost of allostasis and refers to the wear and tear of body functions by allostasis (McEwen, 1998; Sterling & Eyer, 1988). McEwen (1998) elaborates three different responses that lead to allostatic load: frequent stress, failed shut-down (e.g., an unnecessary, prolonged stress response) and inadequate response (e.g., an overreaction towards a minor stressor).

The three proposed theories of stress show a development of reaction-oriented views of stress but lack, however, acknowledgement of stressor characteristics (Brinkmann, 2021).

### *Stimulus-oriented view*

The stimulus-oriented view focuses on the type of situation or stimulus that triggers a stress reaction. Therefore, stress within this view does not refer to the mechanism triggered within the body but to the trigger and its characteristics.

Research regarding stressors' characteristics mainly focuses on life events that describe significant changes in life, which require adaption, like the death of a spouse or divorce (Holmes & Rahe, 1967). Everyday stress, however, is equally important for one's health and refers to demands and relationships which impact our well-being daily and are irritating or frustrating (DeLongis et al., 1988). It can, for example, lead to health problems and mood decline, especially for people with low emotional support and low self-esteem (DeLongis et al., 1988). This emphasizes the interaction between situational and personal characteristics for forming individual consequences of stress. Interestingly, when talking about stress, the focus lies on external stressors. However, psychological processes such as rumination or mental tasks can be equally stressful (Knappe & Hoyer, 2020; Lovallo, 2015).

Combining the reaction- and stimulus-oriented views leads to *relational stress theories* that compare situational demands with individual coping possibilities. According to Lazarus and Folkman (1984), acknowledging the relationship between the environment and an organism leads to a more cohesive and complete understanding of stress. Moreover, the authors emphasize the cognitive process of an individual appraising the environmental demands as one key stress factor. As the second key factor the authors name coping strategies.

### *Transactional model of stress and coping*

Cognitive transactional theories of stress refer to the transaction between a person and the environment in forming stress. More precisely, the interindividual cognitive processes that assess the situation and hence, influence the subsequent reaction. This enables the understanding and assessment of specific and individual reactions to similar situations (Lazarus & Folkman, 1984). The stress model most relevant to this thesis is the *Transactional Model of Stress and Coping* (TSC), developed by Lazarus and Folkman (1984). The model aims to explain inter- and intraindividual stress reactions following a specific stressor by taking into account cognitive appraisals that evaluate the characteristics of the stressor as well as possible coping options (Lazarus & Folkman, 1984; Lovallo, 2015). Appraisals had already been introduced before the conception of the TSC. Their purpose is to help an individual categorize a situation by its advantages or disadvantages (resp. value) for one's wellbeing (Lazarus & Folkman, 1984). Within the TSC, they are commonly understood as evaluations of a situation that reflect beliefs and commitments about the world and have implications for goals (Lovallo, 2015; Schneider, 2008). The TSC

assumes that appraisals determine one's behavioral and cognitive responses as well as neurophysiological, endocrine, autonomic and emotional reactions – taken together: our stress response (Lovallo, 2015). Appraisals are subcategorized into primary and secondary appraisals. The order does not imply their value but only serves to differentiate them (Lovallo, 2015). Figure 1 depicts an overview of the TSC.

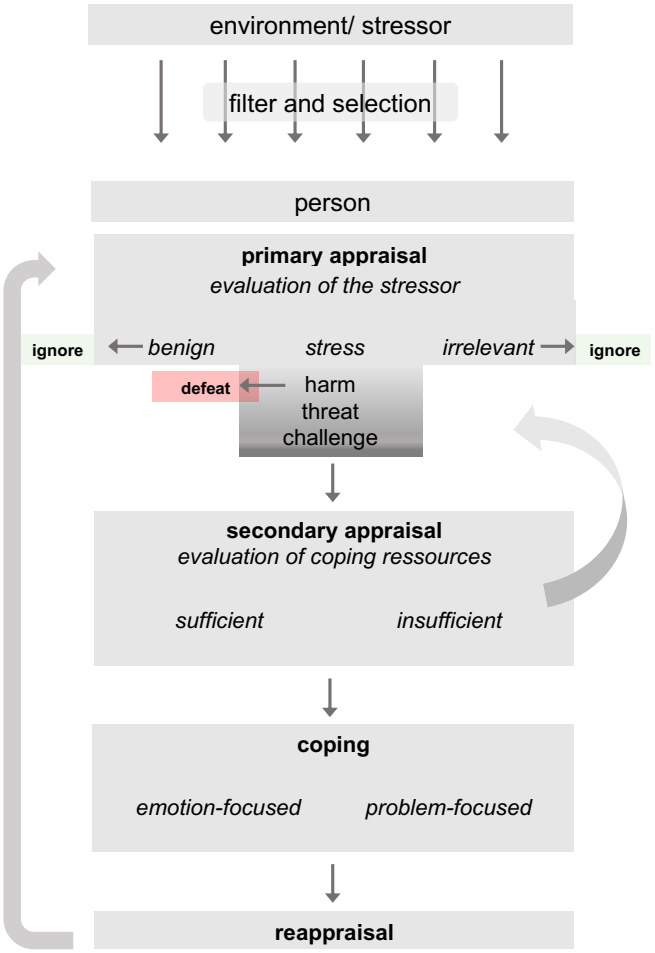
**Primary appraisals.**

Primary appraisals occur after the onset of a stressor and represent a first unconscious, implicit evaluation of the situation using contextual cues (Kilby & Sherman, 2016) for its threat value (Lovallo, 2015), personal significance, and meaning (Lazarus & Folkman, 1984). The primary appraisal is essential as it helps to navigate the world, identify danger and thereby exceeds the mechanisms of basic information processing.

Primary appraisals can be subcategorized into *irrelevant*, *benign/ positive*, and *stressful*. A situation evaluated as irrelevant does not interfere with well-being, neither negatively nor positively. However, situations labelled benign/ positive increase or preserve well-being and are accompanied by pleasurable emotions (Lazarus & Folkman, 1984). Lazarus and Folkman (1984) interestingly note that the benign/ positive appraisal can also, for example, foster anxiety if a person has the mindset that after a positive event, a negative consequence follows. This example highlights the importance of subjective beliefs about the world for appraisals and shows that appraising is a dynamic process with feedback loops. Furthermore, stressors can be appraised as stressful. This appraisal is further categorized into *harm/ loss*, *challenge*, and *threat*. Harm/ loss describes a situation within the concept of stress where illness, injury, damage to self- and social esteem, or the loss of a loved person has already occurred. Therefore, the beliefs or commitments of a person about the world and one’s life, which are highly relevant for the appraisals, are damaged. Threat describes a state where harm or loss can be anticipated and still allows for anticipatory coping. The possibility of anticipatory coping is the main aspect to distinguish it from harm/ loss. Interestingly, the authors also note that even for harm/ loss the threat appraisal plays a dominant role because the losses endured during a harmful situation often have threatful implications for the future. Lastly, challenge is appraised if mobilization and coping efforts are possible. It focuses on potential gains and is also accompanied by positive emotions such as eagerness (Lazarus & Folkman, 1984).

**Figure 1**

*Framework for the Transactional Model of Stress and Coping according to the theoretical considerations by Lazarus and Folkman (1984) and explanations by Lovallo (2015).*




*Note.* This figure depicts the Transactional Model of Stress and Coping following the theoretical considerations by Lazarus and Folkman (1984) and explanations by Lovallo (2015). A person perceives a situation/ stressor through the filter of personal commitments. This stressor is subsequently evaluated for its significance and value (primary appraisal). Furthermore, through secondary appraisal, possible coping resources are assessed that lead to the selection of a coping strategy. After the onset of coping, the situation is reappraised. The Situation is potentially reappraised differently and thereby re-evaluated, depending on how successful the coping was.

It is important to note that threat and challenge are not entirely exclusive either but rather related constructs. If a situation is appraised as challenging, a person is most likely to have a larger sense of control. According to Kilby and Sherman (2016), researchers describe the relationship between challenge and threat as the ratio of available resources and resources necessary, which represents the person's beliefs about the ability to cope with a stressor. Others put it as an evaluation of gains and losses: challenge provides an opportunity for gain, personal growth and learning, but threat poses damage.

Dugdale et al. (2002) found in their study with athletes that the unexpectedness of a stressor influences the appraisal, with more threat appraisal for unexpected stressors than expected ones. Furthermore, Lovallo (2015) highlights that not all stressors are physically harmful, but they can still be appraised as threatful. Therefore, physical (e.g., burning) and psychological stressors (e.g., mental arithmetic tasks) can both be threatful.

**Secondary appraisals.**

Secondary appraisals analyze possible coping options, their applicability, perceived control over a situation, and the likelihood that the coping leads to a desired outcome. It is an evaluation of general possibilities and individual resources. They are relevant if a situation has been categorized as stressful, more precisely, if appraised as a threat or challenge. Possible resources may include personal, social, physiological or material characteristics (Lazarus & Folkman, 1984). The process of secondary appraisal leads to the selection of coping strategies that can roughly be categorized as either *emotion*- or *problem focused* (Lovallo, 2015).

Problem focused coping strategies attack the problem directly by trying to get new information, change the situation or beliefs and commitments. This strategy will most likely lead to an enhancement of personal knowledge, awareness, and behavioral skills. Emotion focused strategies limit the emotional disruption of an individual through psychological changes like suppression. There is minimal to no effort to modify the event itself (Lovallo, 2015).

Problem focused coping is more regularly used if a situation is appraised as challenging. In contrast, emotion focused coping is chosen for situations with little to no perceived options for action (Folkman et al., 1986).

Primary and secondary appraisals interact to determine the magnitude of stress as well as the strength and quality of the emotional response. Secondary appraisal may lead to a reassessment of primary appraisal if the information about coping possibilities changes the evaluation of the situation (Lazarus & Folkman, 1984).

The interaction of primary and secondary appraisal was studied by Franks and Roesch (2006). They found that the type of primary appraisal influenced the secondary appraisal and subsequent coping use for cancer patients. Firstly, the results show that most patients used multiple coping strategies. Secondly, patients that appraised the illness as threatful used more problem focused coping, whereas harm/ loss appraisals were associated with high avoidance coping and challenge appraisal with approach coping. The authors note that the relationship between threat appraisal and problem focused coping is surprising and was rather expected to be associated with emotion focused coping (Franks & Roesch, 2006).

### *Personality factors influencing appraisals*

Personality factors and emotional intelligence are named as the most important influences on stress appraisals (Kilby et al., 2018; Smith & Lazarus, 1990; Tomaka & Magoc, 2021). Personality is usually described with a set of personality traits. Every person shows an individual expression pattern of those traits, forming a specific personality. The traits display characteristics of our thoughts, feelings, and behaviors (Diener & Lucas, 2019; Matthews et al., 2003). One of the most common conception of traits is the *Big Five* (Goldberg, 1990) which describes five personality factors: *openness to experience* (O), *conscientiousness* (C), *extraversion* (E), *agreeableness* (A), and *neuroticism* (N). Studies indicate that especially neuroticism, extraversion, and openness to experience show a strong association with challenge- and threat appraisals (Tomaka & Magoc, 2021).

### Neuroticism

Neuroticism can be described as a tendency to experience a sense of uncontrollability and negative affect, especially when frustrated, threatened, or facing loss. People scoring high on N have an intensified stress reactivity and vulnerability compared to people that express lower N (Barlow et al., 2014; Ormel et al., 2013). According to Barlow et al. (2014), a general biological and general psychological vulnerability influences a dysregulated stress response, leading to the expression of N. General biological vulnerability includes the tendency for an exaggerated reactivity

in brain structures associated with emotion processing, most notably the amygdala. This increased reactivity is accompanied by limited inhibitory prefrontal control. Genetic factors and stressful/ traumatic experiences during critical developmental stages influence this very pattern of neurobiological reactivity (Barlow et al., 2014). Moreover, general psychological vulnerability describes the tendency to experience stressful situations as uncontrollable and unpredictable, which is accompanied by the perceived inability to cope (Barlow et al., 2014). As mentioned above, the unexpectedness of a stressor –similar to unpredictability and uncontrollability – facilitates increased threat appraisal, which could add to the enhanced experience of negative affect followed by stress (Dugdale et al., 2002). Therefore, the authors stress a dynamic and non-unidirectional resp. causal, conceptualisation of the vulnerabilities leading to the expression of N, and highlight the inclusion of environmental influences (Barlow et al., 2014)[1].

N is especially interesting for stress research because of the reported increased stress reactivity. There is a large amount of research that studied the association between N and *cortisol* (a stress marker for the reactivity of the *HPA axis*), which, interestingly, cannot draw a precise conclusion as there is little concrete evidence for a dysregulation of the HPA axis in individuals with high-N (Ormel et al., 2013; Verschoor & Markus, 2011). Moreover, a study by Puig-Perez et al. (2016) showed no significant relationship for the *autonomic nervous system* (ANS, for example heart rate variability) and N in elderly subjects after the TSST. More precisely, the authors investigated heart rate variability and heart rate recovery (Puig-Perez et al., 2016).

However, research indicates adverse outcomes that accompany the stress reaction. Kendler et al. (2004) found that N moderates the negative effects of incisive life events: leading to an increased vulnerability for high-N individuals to develop depression following such life events. Furthermore, Hutchinson and Williams (2007) report that high-N individuals experience an increased risk of developing depressive symptoms when exposed to daily hassles. And after an acute laboratory stress task,

[1] Note that N is a highly complex expression of multiple personality facets and its diathesis depicted above it simplified to highlight important factors relevant for this thesis.

individuals with high-N responded with more negative affect than participants with low-N (Schneider, 2004; Verschoor & Markus, 2011; Xin et al., 2017). Moreover, studies also show that high-N individuals report an increased subjective stress response after an acute laboratory stress task (Bibbey et al., 2013).

In line with that, studies point out attentional biases for high-N individuals. According to Ormel et al. (2013) they show increased attention towards harmful or threatening information, as well as slower disengagement from the same. Interestingly, this effect is more prominent under stressful conditions. Another factor that might promote the negative affective outcomes listed above is the increased use of ineffective coping and decreased use of reappraisal in response to a stressor for high-N individuals (Gross & John, 2003; Suls & Martin, 2005).

Altogether, on the one hand, studies show relatively clear results for an increased negative affect in high-N individuals in the context of stress. On the other hand, there are ambiguous results regarding the influence of N on the physiological stress response, e.g., the HPA axis and ANS.

### *Neuroticism and stress appraisal*

As listed above, several mechanisms may lead to a specific pattern of subjective stress response for high-N individuals. Another prominent factor for an increased subjective stress response, besides attentional biases and inefficient coping strategies, could be their tendency to appraise stressors as threatening (Suls & Martin, 2005). Tomaka and Magoc (2021) concluded in their recent study that Big Five personality traits, such as N, are robust predictors of individual appraisal tendencies. According to the *neurotic cascade model* by Suls and Martin (2005), persons with a high expression of N exaggerate the level of threat a stressor conveys (primary appraisal) and conversely underestimate personal resources (secondary appraisal) (Gunthert et al., 1999). These perception biases lead to an intensified stress reaction. The neurotic cascade model's assumption is supported by Tomaka and Magoc (2021). Their results from a study with 737 firefighters show that N is positively related to the recurrent tendency to make threat appraisals. Furthermore, their results indicate that people with high-N are more likely to rate everyday requirements as demanding without optimistic coping strategies. In line with that, Schneider (2004) and Schneider et al. (2012) found only N of the Big Five to predict threat appraisal. The authors also introduced the mediating role of threat appraisal for the association between high-N and increased negative affect (Schneider, 2004)

as well as for the association between high-N and decreasing task performance (Schneider et al., 2012) after a laboratory stressor.

These findings indicate a crucial role of threat appraising in understanding the susceptibility towards stress in individuals with a high expression of N. This is especially important as stress is a leading risk factor for adverse psychological and physical health conditions (Schneiderman et al., 2005). Moreover, threat appraisal plays an essential role in developing a psychological disorder (Britton et al., 2011), and reappraisal is a significant component in cognitive-behavioral therapy for psychological disorders (Smits et al., 2012). Therefore, understanding the mechanisms that lead to enhanced stress reactivity and susceptibility, possibly through threat appraisal of high-N individuals, is necessary for the prevention and intervention of psychological disorders, as they might be less vulnerable towards stress if they had different appraisal strategies (Schneider, 2004).

**Physiology of stress**

To classify the outcome “stress” it is helpful to have a closer look at the physiological changes following a stressor, called stress reaction. As explained above, the literature postulates an individual stress response, different to what Selye (1976) described as the G.A.S. Selye was right, however, to use the term “adaption”, as a mechanism triggered in an organism after a stressor are adaptive to meet the situational requirements. Stress greatly involves three main systems in humans: the autonomic nervous system, the hypothalamic-pituitary-adrenal axis, and the immune system (Kemeny, 2003).

The ANS and *adrenal medulla* (resp. enteric nervous system) form the *sympathetic adrenomedullary system*. Furthermore, the ANS consists of two counterparts: the sympathetic nervous system (fight-or-flight) and the parasympathetic nervous system (rest-and-digest). The sympathetic nervous system triggers involuntary processes to prepare the body for threat. Therefore, *norepinephrine* is released into the blood through different organs (e.g., adrenal medulla), which in turn leads to the release of *epinephrine*, also known as adrenaline. The sympathetic nervous system responds rapidly and unconsciously to unexpected changes (Kemeny, 2003). Moreover, the sympathetic activation triggers the enteric nervous system and thereby inhibits digestion. Taken together, the sympathetic and parasympathetic nervous systems complement each other in their functions, although they use different anatomical structures and pathways (Bear et al., 2020).

The *hypothalamic-pituitary-adrenal axis* (HPA axis) reacts to neural messages that convey the perception of stress by releasing the *corticotropin-releasing hormone* (CRH). The CRH neurons are controlled by the amygdala (activation) and hippocampus (suppression) that function as the feedback regulation system of the HPA axis. CRH releasing hormone stimulates the pituitary gland, which in turn releases the *adrenocorticotropic hormone* (ACTH). ACTH triggers the outer layers of the adrenal gland to release *glucocorticoid cortisol* (Kemeny, 2003). Cortisol mobilizes energy resources in the body to provide it as needed for adaptation processes (Kemeny, 2003). Compared to the ANS, the HPA axis does not respond as quickly as the ANS, and it can take up to 40 minutes to reach a peak in the cortisol levels (Kemeny, 2003). Chronic activation of the HPA axis leads to negative health outcomes, which illustrates the harmful effect of constant stress (Allen et al., 2014). The HPA axis is often associated with psychosocial stressors, and the release of cortisol is a common stress index. To analyze another possible stress index which is also retrieved from saliva sampling but is rather indicative of the ANS, *salivary flow rate* (SFR) has recently sparked interest.

**Salivary flow rate**

Saliva consists of 99% water; the average flow rate is 0.3 mL/min. The secretion of saliva is controlled by the salivary nuclei (superior and inferior) located in the medulla that triggers the minor and major salivary glands, which are responsible for secretion (Feher, 2017; Humphrey & Williamson, 2001). The primary triggers for saliva secretion are tactile, gustatory, visual and olfactory stimuli (Rohleder et al., 2006). Additionally, salivary flow can also be influenced by higher brain areas like the forebrain or hypothalamus when tired, dehydrated, or fearful (Feher, 2017). The salivary glands are innervated by sympathetic adrenergic as well as parasympathetic cholinergic nerves that synapse with preganglionic fibers from the salivary nuclei. With a stronger sympathetic tonus, the glands produce less saliva that contains more proteins, whereas parasympathetic stimulation increases flow with a waterier consistency (Feher, 2017; Humphrey & Williamson, 2001). Therefore, the amount of protein depends on sympathetic nerves and the release of noradrenalin, especially for saliva secreted from major glands; the simple fluid secretion is mainly influenced by parasympathetic nerves (Feher, 2012; Proctor & Carpenter, 2014). In conclusion, saliva secretion is a complex process influenced by different pathways and

mechanisms within the body. Both sympathetic and parasympathetic nerves influence the reflex secretion of saliva (Pedersen et al., 2018).

Various exogenous factors further influence salivary flow. Different research groups list several influences: individual hydration, medications and disease, nutrition intake and fasting, gender, body weight and size (as it influences gland size), age, consumption of alcohol, smoking, physical exercise and thinking about food or visual stimulation. Moreover, the literature suggests that SFR is at a minimum level during sleeping hours and peaks during daily food consumption. In addition, there generally is a lower SFR during summer and a higher flow during winter (Bellagambi et al., 2020; Humphrey & Williamson, 2001; Inoue et al., 2006). The influences are important to consider – or control for – when SFR is used as a stress index.

The idea to consider salivary flow rate as a stress marker stems from the assumption that stress leads to an increased sympathetic stimulation of the salivary glands and therefore to a decrease in salivary flow, which is mostly dependent on parasympathetic stimulation. This approach assumes that sympathetic and parasympathetic stimulation inhibits each other as counterparts. However, there is limited and mixed empirical support for that hypothesis (Rohleder et al., 2006). In addition, it is challenging to compare the studies that explore the effect of stress on SFR due to various sampling methods and timing as well as different types of stressors. Many studies do not collect SFR as a primary stress index, which influences sampling methods and the exclusion criteria for participants. As described above, various factors influence SFR, and to analyze it as a primary index, there should be exclusion criteria set correspondingly. Otherwise, the informative value might be limited because confounding effects will influence the data (e.g. weight, gender).

Studies that examined SFR in response to a natural stressor (exam) showed no significant change in *unstimulated whole salivary flow rate* (UWSFR) right before an important exam (Bosch et al., 1996) or a significant decrease in UWSFR on the day of an examination (Queiroz et al., 2002) in comparison to baseline UWSFR. Furthermore, Queiroz et al. (2002) examined the influence of postmenstrual syndrome (PMS, which poses a stressful situation for women) on SFR and found no significant change. Bosch et al. (2003) found a reduced SFR after a memory task but increased SFR after watching a surgical video. In contrast, Takai et al. (2004) did not report a significant change in SFR for watching stressful or soothing videos.

Moreover, Nater et al. (2006) reported a slight, non-significant decrease in stimulated SFR after the Trier Social Stress Test (TSST). Interestingly, Bakke et al. (2004) showed an increase in SFR after a color word task with a pronounced effect for the elderly, which is in line with the findings by Rohleder et al. (2006) that show a slight increase for male participants after a TSST. Moreover, Nagy et al. (2015) found a decrease in SFR during a memory search task. Lastly, Li and Gleeson (2004) reported a decreased UWSFR after physical exercise compared to a baseline. Ultimately, the results are inconclusive and difficult to compare, as explained earlier. Table 1 depicts an overview of the mentioned studies with their type of stressor, sampling method, and results.

Different researchers tried to find an explanation for varying results regarding SFR after a stressor, and one possible explanation refers to the synergistic effect of the parasympathetic and sympathetic nervous system on the salivary glands (Bosch et al., 2003; Rohleder et al., 2006). Moreover, a distinction between psychological and physical arousal is proposed, with a decrease in SFR for physical activity (physical stress, exercise) and an increase in SFR for acute psychological stressors (Li & Gleeson, 2004; Rohleder et al., 2006). Contrary to this assumption, Queiroz et al. (2002) explain their reported decrease in the SFR before an exam by the sympathetic influence which is triggered by anticipatory anxiety. Furthermore, concerning the sampling time of SFR, Nagy et al. (2015) report a possible rebound of the SFR after a stressor that exceeded baseline levels which was compared to a vagal rebound. Accordingly, rebounding effects of the parasympathetic nervous system increase SFR after a stressor, possibly misleading the interpretation of results (Nagy et al., 2015).

**Table 1**
*Overview of recent findings about salivary flow rate (SFR) and participants, sampling method and type of stressor.*

| | Participants (gender) | Sampling method | Stressor | Δ in SFR (significance) | Effect size |
|---|---|---|---|---|---|
| Bosch et al. (1996) | 28 *f,m* | Spitting method | Exam | Slight decrease* | - |
| Queiroz et al. (2002) | 71 *f,m* | Spitting method | Biochemistry exam | Decrease** | - |
| | 23 *f* | Spitting method | Premenstrual syndrome | Slightly higher for women with PMS* | - |
| Bosch et al. (2003) | 32 *m* | Spitting method | Memory task | Decrease ** | - |
| | | | Surgical video watching | Increase** | - |
| Takai et al (2004) | 83 *f,m* | Spitting method | Surgical video watching | No Change* | - |
| Nater et al. (2006) | 30 *m* | Salviette | TSST | Slight decrease* | - |
| Bakke et al (2004) | 26 *f* | Draining method | Color word task | Increase** | - |
| Nagy et al. (2015) | 34 *f,m* | Spitting method | Memory-search task | Decrease** | $\eta_p^2 = .59$ |
| Li and Gleeson (2004) | 8 *m* | Expectoration | Cycling | Decrease** | - |

*Note.* Gender *f* refers to female and m to male.No studie made a distinction between male, female and divers. An effect size for statistical results was only presented by Nagy et al. (2015) for a significant effect of time on SFR.
* $p > .05$
** $p < .05$

**Relationship between neuroticism, primary appraisal, stress, and salivary flow rate**

This section discusses the (potential) relationship between neuroticism, appraisals, stress, and SFR. As described earlier, the TSC is one of the most important and holistic theories regarding stress. The process of primary appraisal influences individual stress responses by evaluating a given situation for its value by taking in personal beliefs and commitments (Lazarus & Folkman, 1984). A study by Gaab et al. (2005) found stress appraisals to explain 22 % of the variance in cortisol after a social stress task (TSST). Moreover, Schneider (2004) found that high-N individuals responded with more negative affect after a stressor than participants with low-N. The association between stress and increased negative affect was mediated by threat appraisal. In general, people with high-N scores tend to evaluate a situation as more threatening (Suls & Martin, 2005; Tomaka & Magoc, 2021). Concluding from this, threat appraisal seems to mediate the association between increased stress reactions and adverse outcomes for people with high-N scores. To my knowledge, no study yet describes threat appraisal as a mediator for the relationship between N and the intensity of the increase in subjective as well as physiological stress response after a laboratory stressor.

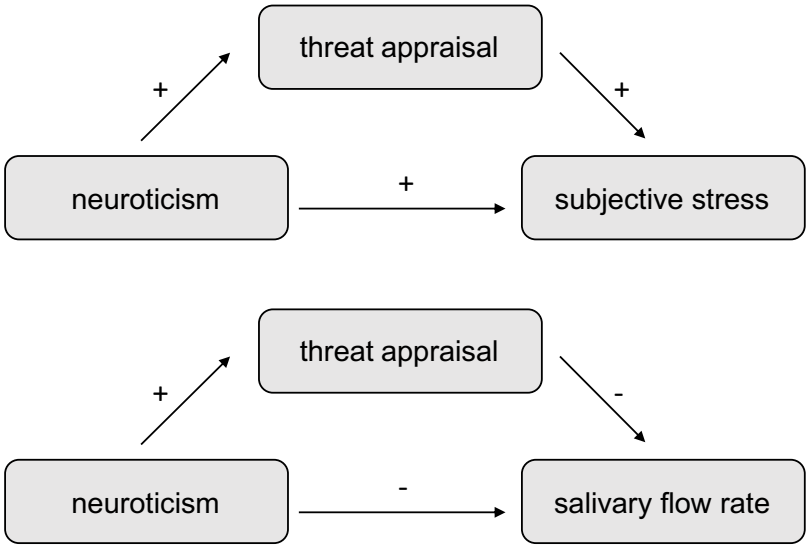
As discussed above, limited evidence exists for increased HPA reactivity in participants with high-N (Ormel et al., 2013; Verschoor & Markus, 2011). Moreover, the study by Puig-Perez et al. (2016) showed that high-N individuals exhibit no greater ANS reactivity after the TSST than individuals with lower expressions of N. There are, however, indications that N is associated with increased negative affect (Schneider, 2004; Verschoor & Markus, 2011; Xin et al., 2017) and enhanced subjective stress (Bibbey et al., 2013) following a stressor. In this thesis, I will further investigate the assumption that N positively predicts the increase in subjective stress levels in response to a stressor. Moreover, since there is limited evidence for an association between N and HPA-, as well as ANS reactivity after a stressor (Ormel et al., 2013; Puig-Perez et al., 2016; Verschoor & Markus, 2011), SFR is used as a physiological stress index. SFR is a promising and well-assessable marker of the autonomous nervous system and therefore, more research on SFR in association with stress is needed.

Deduced from the existing literature, the assumed connection between N, threat appraisal and subjective stress, resp. SFR is as follows: N positively predicts

the stress response (subjective stress or SFR) through high threat appraisal. Thereby, subjective stress is expected to increase with higher expressions of N. Moreover, SFR is expected to decrease with higher expressions of N. This assumption is based on earlier findings (Bosch et al., 2003; Nagy et al., 2015) and the theory that an increase in stress leads to a more prominent sympathetic tonus on the salivary glands and, therefore, a decrease in SFR (Rohleder et al., 2006). Figure 2 illustrates the assumed connection.

**Figure 2**

Assumed effects of neuroticism on subjective stress and salivary flow rate, mediated by threat appraisal.




*Note.* This figure illustrates the expected associations between neuroticism and subjective stress, resp., salivary flow rate after an active laboratory stressor. While subjective stress is expected to increase (+) with rising neuroticism scores, the salivary flow rate is expected to decrease (-) with rising neuroticism scores. These two associations are expected to be mediated by threat appraisal.

**Research question and hypotheses**

This thesis addresses the question how N affects the change in subjective stress and SFR in individuals after an active laboratory stressor compared to a baseline; and if these effects are mediated by threat appraisal. This results in the following research questions:

**Q1:** What is the effect of neuroticism on the change in subjective stress after an active laboratory stress task compared to a baseline?

**Q2:** What is the effect of neuroticism on the change in salivary flow rate after an active laboratory stress task compared to a baseline?

**Q3:** Is the effect of neuroticism on subjective stress, resp. salivary flow rate mediated by threat appraisal?

We expect high levels of N to be associated with increased subjective stress. Moreover, we expect N to positively predict threat appraisal and threat appraisal to mediate the association between N and subjective stress. As a result, we make the following hypotheses[2]:

**H1.1:** Neuroticism is positively associated with subjective stress.

**H1.2:** Neuroticism positively predicts threat appraisal.

**H1.3:** Threat appraisal positively predicts subjective stress.

**H1.4:** The positive association between neuroticism and subjective stress is mediated by threat appraisal.

Furthermore, we expect high levels of N to be associated with a decrease in SFR. Thereby, we expect N to positively predict threat appraisal as well and threat appraisal to mediate the association between N and SFR. As a result, we make the following hypotheses[3]:

---

[2] Note that the hypotheses represent the pathways of the mediation model tested later and are specified accordingly.

[3] Note that the hypotheses represent the pathways of the mediation model tested later and are specified accordingly.

**H2.1:** Neuroticism is negatively associated with salivary flow rate.

**H2.2:** Neuroticism positively predicts threat appraisal.

**H2.3:** Threat appraisal negatively predicts salivary flow rate.

**H2.4:** The negative association between neuroticism and subjective stress in mediated by threat appraisal.

## Method

### Participants

The simulation-results for required sample sizes in mediation analysis' (with a power of 80 %) by Fritz and Mackinnon (2007) show an estimated sample size of 59 for an LM[4] effect. The effect size for the alpha pathway was drawn from Schneider (2004), which found N to positively predict threat appraisal (large effect with β = .62). The effect size for the beta pathway was drawn from Chu et al. (2022) who found threat appraisal to positively predict subjective distress (medium effect with β = .43). Participants were primarily recruited through the Vienna CogSciHub which is a study participant platform, and social media postings as well as personal communication. The recruiting flyer for the project included information about the study duration- and topic, broad inclusion criteria, as well as the monetary compensation of 45 €. Participants had to be healthy, 18 – 35-year-old females that spoke German fluently and were neither pregnant nor breastfeeding nor used hormonal contraception. Moreover, they needed to have a regular cycle and normal BMI. Generally, factors influencing participants' hormonal balance were set as exclusion criteria. In addition, chronic diseases, psychological disorders, surgery in the last eight weeks, vaccination in the previous two weeks, allergies concerning the skin, and impaired eyesight led to exclusion. Candidates that smoked had an increased alcohol consumption (more than eight glasses per week), took medication, or used drugs could not participate. Furthermore, participants were required to have an unimpaired hearing but were neither allowed to have absolute hearing nor work as professional musician. In addition, experience with the TSST also led to exclusion. The study's

[4] LM refers to a large effect for the alpha-, and a medium effect for the beta-pathway.

main purpose was to investigate the effect of music on stress recovery; therefore, these exclusion criteria were set accordingly. Moreover, a close relationship with a study team member led to exclusion to avoid the effects of social support. The criteria were assessed by a study team member via a telephone interview screening. The candidate was included if all inclusion criteria were met and no exclusion criteria applied. After that, study dates in the participants follicular cycle phase were arranged and subjects were randomly assigned to one of the three conditions.

Due to the COVID-19 pandemic, all participants were also required to provide evidence of immunity or a negative PCR test. All study team members and participants had to wear an FFP2 mask to minimize the danger of infection. If anyone attending the testing showed or had shown, signs of infection within 14 days, the testing was terminated.

**Study design**

The research questions were addressed as a secondary analysis within a research project by Dr.[in] Jasminka Majdandžić and Univ. Prof. Dr. Urs Nater that focuses on the effects of music listening on stress and skin barrier recovery. Participants were randomly assigned into three groups to address the study's main research question: music listening (main independent variable), audiobook listening or silence (control groups). Stress was measured through various outcomes: subjective stress information, cortisol and alpha-amylase, heart rate variability as well as electrodermal activity. To identify the effects of music listening on wound healing (as an indicator of the immune function) after a stressor, skin barrier recovery derived from repeated *transepidermal water loss* measurements (TEWL) was assessed as the main outcome.

Moreover, the study collected data about life stress, stress reactivity, state- and trait anxiety as well as abuse and neglect during childhood. Information about coping styles, emotional regulation, resilience, self-esteem, and personality traits was collected as psychological factors. In addition, the most common mental disorders, premenstrual syndrome, and fatigue, were checked for. Lastly, information was gathered about music preference, musicality, the cognitive style of music listening, music-related mood-regulation strategies, and absorption. The variables were assessed with an online questionnaire that participants had to complete in advance. On the one hand, the collected information served as a source for further analysis and, on the other hand, was used to control for confounding influences.

**Procedure**

The study started after the described telephone screening with several questionnaires the participants had to fill out in advance. Life stress and stress reactivity was assessed by using the *Trier Inventar zum chronischen Stress* (TICS; Schulz & Schlotz, 1999) for chronic stress, the *Perceived Stress Scale* (PSS; Cohen et al., 1983) for subjective perceived stress, the *State-Trait Anxiety Scale* (STAI-S & STAI-T; Spielberg et al., 1981) for state and trait anxiety, the *Childhood Trauma Questionnaire* (CTQ; Bernstein et al., 1994) for abuse and neglect in childhood, and the *Perceived Stress Reactivity Scale* (PSRS; Schulz et al., 2005) for stress reactivity. Coping was assessed using the *Brief-Cope* (Carver, 1997) and emotion regulation using the *Emotion Regulation Questionnaire* (ERQ; Gross et al., 2003). Resilience was measured with the *Resilienz- Kurzskala* (RS-11, Schumacher et al., 2005). Information about the personality traits was collected using the *NEO-Five-Factor-Inventory* (NEO-FFI, Costa & McCrae, 1992) and the *Rosenberg Self-Esteem Scale* (RSES; Rosenberg, 1965) to evaluate self-esteem. Health and well-being were assessed using the *Prime MD Patient Health Questionnaire* (PHQ-D; Gräfe et al., 2004) to screen for the most common mental disorders and the *Beck's Depression Inventory* (BDI-II; Beck et al., 1996) for depressive symptoms. Functional-, and somatic symptoms as well as premenstrual syndrome were assessed using the *Premenstrual Syndrome Impact Questionnaire* (PMS_I; Kues et al., 2016) and the *Multidimensional Fatigue Inventory* (MFI-20; Westenberger et al., 2022). Several constructs regarding music were measured with the *Music Preference Questionnaire* (MPQ; Nater et al., 2005); the *Gold-MSI* to assess trait musicality (G-MSI; Müllensiefen et al., 2014), the *Music-Empathizing-Music-Systemizing (ME-MS) Inventory* (MEMS; Linnemann et al., 2018), the *Brief Music in Mood Regulation Scale* (B-MMR; Saarikallio, 2012) and the *Tellegen Absorption Scale* (TABS; Tellegen et al., 1981).

The experiment consisted of various components, which can be roughly subdivided: Saliva samples were collected eight times, and questionnaires were handed out in the meantime. In addition, transepidermal water loss was measured five times. To induce stress, a stress test was also performed, followed by a rest period in which the participants listened to either music or an audio book or nothing. Between the later measurements during the experiment, there were rest periods in

which magazines could be read. Figure 3 shows the simplified timeline of the study that depicts the measures necessary for this thesis. The study protocol is as follows:

Participants were asked to arrive at 12:50 pm on the day of the experiment. The experiments were conducted following the applicable COVID-19 requirements. Moreover, participants and the study team were always required to sanitize their hands, measure their temperature upon arrival and wear FFP2 masks. The participants were allowed to remove their masks if required for the testing. As soon as the COVID-19 precautions were checked and met, participants gave their informed consent and filled out an entry questionnaire. Afterwards, preparations for the saliva sampling were taken (e.g., mouth rinse) and after a detailed explanation of the saliva release by the experimenter, a trial run was done. Moreover, to measure the heart rate variability and electrodermal activity the EdaMove 4 and EcgMove 4 by movisense® (Karlsruhe, Deutschland) sensors were attached to the wrist, resp. lower chest[5]. Participants were instructed to set a marker on the EdaMove 4 wrist sensor for every of the 8 following measurements. For the skin barrier recovery measures, the area just below the elbow crease of the non-dominant arm was marked by a stamp. Depending on the condition, the subjects selected their preferred music genre or the audio book's topic out of multiple options. Also, the volume of the headphones was adjusted here. For the silence condition, this part was skipped. All participants, however, later wore headphones during the 30-minute music-or audiobook listening, resp. silence.

Following the preparations, at around 1:25 pm, the first of the eight measures were taken: subjects were asked to set the marker, perform the saliva sampling, and fill out several questionnaires. The set of questionnaires consisted of the *Mehrdimensionaler Befindlichkeitsfragebogen* (MBDF; Steyer at al., 1994), the *Types of Positive Affect Scale* (TTPAS) and the *visual analogue scale* (VAS; Lesage et al., 2012). To assess multiple facets of stress the VAS is used to asses stress all together, controllability, anxiety, urge to leave the situation as well as tension.

---

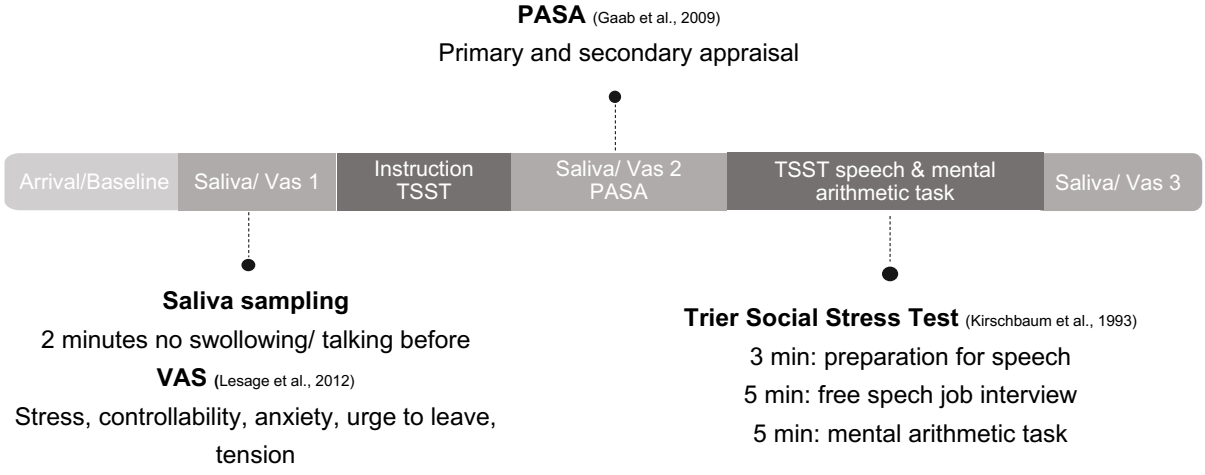
[5] Please note that the fitting of the sensors was always performed by a female, either the experimenter or the person taking the TEWL measurement. The person performing the TEWL measurements always had to be female.

Moreover, VAS is used to restrospectively evauate the situation when the TSST is performed. Following the measurements, the experimenter and participants changed the room and the *Trier Social Stress Task* (TSST, Kirschbaum et al., 1993) was performed: After the first instructions and a preparation phase the participants concluded their second measurements at around 1:40 pm. In addition to the measurements listed above, the *Primary Appraisal Secondary Appraisal* (PASA, Gaab et al., 2009) was filled out. Subsequently, the TSST was performed, and the experimenter left the room and only entered after the third measurement. The third measurement was instructed at approximately 1:55 pm by the primary stressor of the TSST committee. In addition to the questionnaires listed for the first measure, the retrospective VAS (Gaab et al., 2009) was filled out.

After the stress task the baseline TEWL measures were taken, followed by the tape-stripping procedure to impair the skin. The fourth measure was conducted at around 2:20 pm and was performed analogously to the first measurement. Afterwards, the music, or audiobook listening resp., silence took place for 30 minutes in a lying position. Following this session, four more measurements were taken, each 30 minutes apart. Each measure was conducted analogously to the first measure with additional TEWL measurements. The experimenters left the room during the 30-minute resting period and participants were offered to read magazines in a sitting position. After the eight measurements, participants got a debriefing, filled out a form to receive monetary compensation, and left at approximately 4:40 pm.

**Figure 3**

*Time sequence of measurements and tasks relevant for this thesis.*




*Note*: This figure only displays the relevant measurements during the experiment necessary for the analysis of this thesis' hypotheses. Therefore, it is a simplified and shortened timeline of the full experiment. After the arrival of the participants and several baseline measurements and demonstrations were conducted, the first measurement (saliva sampling and VAS) took place. Afterwards, the introduction for the stress test (TSST) was followed with the second measurements (saliva sampling, VAS, and PASA) subsequently. Right after that, the stress test took place which was followed by the third measurement (saliva sampling and VAS).

## Task

### *Psychosocial stress test/ Trier Social Stress Test*

The TSST (Kirschbaum et al., 1993) is a well evaluated psychosocial stress paradigm that combines multiple components contributing to an observed stress response (social evaluation, mental arithmetic, public speaking, and anticipation) (Allen et al., 2014; Kirschbaum et al., 1993). The TSST follows a protocol that includes three different phases. In phase one, participants are instructed to prepare for a simulated interview (for a job they are eager to get) and take notes for three minutes. Afterwards, they must perform a 5-minute free speech – without using the notes taken beforehand – highlighting their personality factors which qualify them for the desired job. Lastly, subjects are asked to perform a mental arithmetic task,

subtracting from 2043 in steps of 17 for 5 minutes. A committee observes all three tasks. The participants are informed that the committee is instructed and trained for behavioral analysis and that the procedure is videotaped – both to increase the effects of social evaluation (Kirschbaum et al., 1993). The committee consisted of a male active stressor who verbally interacted with the participant by giving instructions and negative or neutral feedback as well as taking notes. Feedback for the interview, for example, might remind the subject to focus on personal characteristics rather than previous experience. Moreover, there was a female passive stressor that took notes. Both stressors had to keep a neutral face and avoid interaction that might facilitate social support. In addition, the experimenter was told to interact neutrally with the participants to prevent social support before and after the stress task. After the entire experiment was finished, participants were informed that there were no video recordings, and the committee were not behavioral observers but students.

The TSST has been found to increase the HPA-axis activity and ANS activity (Allen et al., 2014). Studies also report increased self-reported stress as well as anxiety and a shift towards negative affect following the TSST (Allen et al., 2014). Therefore, an expected increase in subjective stress and sympathetic nervous system activity can be reliably induced with the TSST for this study. It is important to note, however, that several factors influence the effect of the TSST on stress outcomes. One of the main reported influences is gender and for female subjects the intake of hormonal contraception as well as the current cycle phase. Therefore, subjects in this study were tested in their follicular phase and did not use hormonal contraception, as proposed by Allen et al. (2014).

## Measures

### *Neuroticism*

Neuroticism was operationalized using the 12-item, 5-point Likert *Neuroticism scale* from the *NEO-Five-Factor-Inventory* (NEO-FFI) by Costa and McCrae (1992). The NEO-FFI is based on the Big Five model about personality and consists of 60 items with 12 items representing a personality trait respectively. For this study, we used the German translation by Borkenau and Ostendorf (1993). The authors published a validated, revised version of their translation in 2007 and report a good Cronbach's alpha with $\alpha = .87$ for the neuroticism scale (Kanning, 2009). An analysis of our sample also shows a good Cronbach's alpha with $\alpha = .86$ with 45 included participants. Körner et al. (2008) present population-based standard values for the

German version of the NEO-FFI by Borkenau and Ostendorf (1993). The authors report a mean value for the neuroticism scale of *M* = 19.5 with a standard deviation of *SD* = 7.4 for a representative, cross-gender sample. The items are statements that can be scored from 0 (totally disagree/ Starke Ablehnung), 1 (disagree/ Ablehnung), 2 (neutral/ Neutral), 3 (agree/ Zustimmung) to 4 (totally agree/ Starke Zustimmung) by the participants. Subsequent analyses were based on a sum score for each participant across all 12 items, with a higher score indicating a higher expression of N. The Items N1, N4, N7 and N10 had to be reversed and were coded respectively via the platform we presented our questionnaires with. An example for a non-reversed item is ‘Ich fühle mich anderen oft unterlegen‘ and for a reversed item ‘Ich fühle mich selten einsam oder traurig‘.

***Threat appraisal***

Threat appraisal was measured with the 4-item, 6-point Likert *threat scale* from the *Primary Appraisal Secondary Appraisal* (PASA) questionnaire by Gaab (2008). The questionnaire assesses situational cognitive appraisals according to Lazarus’ and Folkman’s transactional model of stress and coping. It is designed to assess situation-yet disorder-unspecific cognitions within cognitive-behavioral therapy. According to the author, however, the PASA can be used whenever subjective stress needs to be evaluated in relation to a specific situation (Gaab, 2008, p. 114). The secondary scale ‘primary appraisal’ includes the primary scales ‘Threat’ and ‘Challenge’; the secondary scale ‘secondary appraisal’ consists of the primary scales ‘Concept about ones’ abilities’ and ‘Control-convictions’. The Cronbach’s alpha of the threat scale shows good internal consistency with α = .83 (Gaab, 2008; Gaab et al., 2005). An analysis for our sample also shows a good Cronbach’s alpha of α = .80 with 42 included participants. The study from Gaab et al. (2005) reports that the primary appraisal scales ‘Threat’ and ‘Challenge’ were significant predictors of the cortisol response with respect to increase after a stressor. These findings indicate that the scale can be used to investigate if threat appraisal predicts stress outcomes.

For the PASA, participants must rate various statements about the situation on a 6-point Likert scale: from 1 (ganz falsch/ completely wrong), 2 (ziemlich falsch/ rather wrong), 3 (etwas falsch/ somewhat wrong), 4 (etwas richtig/ somewhat right), 5 (ziemlich richtig/ rather right) to 6 (ganz richtig/ completely wrong). The Threat scale consists of the items 1, 5, 9, and 13, whereas items 1 and 9 must be recoded.

Subsequent analyses were based on a mean score for each participant across all four items, when a minimum of three items were completed. An example for a non-reversed item is ‘Diese Situation ist mir sehr unangenehm‘ and for a reversed item ‘Ich fühle mich durch diese Situation nicht bedroht‘.

***Subjective stress response***

Subjective, self-reported stress was assessed with the single-item *Visual Analogue Scale* (VAS; (Lesage et al., 2012). The scale is a 10 cm long line representing 100 different expressions of subjective stress with 0 indicating minimum- and 100 maximum stress experience. Participants mark their individual experience on the scale, answering the question ‘Wie sehr fühlen Sie sich gestresst?’. In contrast to the NEO-FFI and PASA, which are presented only once during the study, participants complete the VAS a total of eight times during the experiment. Therefore, it was possible to evaluate a change in subjective stress. For the subsequent analysis, the first (Baseline) and third (after stressor) VAS were used to calculate the change. The individual value for each participant was calculated as follows: $\Delta$ *subjective stress* = subjective stress $_{VAS3}$– subjective stress $_{VAS1}$. As a result, the outcome subjective stress is the delta between the third and first self-reported subjective stress.

***Salivary flow rate***

Saliva was collected using SaliCaps® (IBL International, Hamburg, Germany). Participants were asked to avoid exhausting physical activity and chewing gum within 24 hours before the laboratory appointment. Moreover, they had to avoid smoking, coffee, tea, soft drinks, juices, and alcohol within 18 hours before the testing. Lastly, participants were asked to refrain from eating or brushing their teeth within one hour beforehand. During the experiment, the experimenter ensured that if the subjects were thirsty, they drank water at least ten minutes before the following saliva collection. Before the first saliva sampling, which was a test trial, participants were asked to rinse their mouth with tap water to remove any residues. After that, the experimenter explained the saliva collection procedure and performed a trial run with the subjects: they were asked to refrain from speaking and swallowing for two minutes while filling out questionnaires and letting the saliva accumulate. Participants were not asked to stimulate any saliva production. After 1:40 minutes, the experimenter told the participants to remove the straw from its packaging and take

the tube from the rack. After 2:00 minutes, they were asked to transfer all saliva into the SaliCaps® with the help of the straw and close the tube tightly. For each sampling timepoint there was a pre-labelled and pre-weighted SaliCap®. The individual label contained the participant code and the timepoint (e.g., participant 33_031 and timepoint 01). Timepoints 1 (baseline) and 3 (right after the stressor) are relevant for the following analyses. After the experiment, all SaliCaps® were individually weighted and the difference between the empty and full tube was determined.

Therefore, the used sampling method can most likely be classified as a spitting method, according to Bellagambi et al. (2020) but without repetition. There is little stimulation as the subjects were asked to passively let the saliva accumulate and only spit it out once. Thus, the effects of the sampling method may be considered more similar to those of the passive drooling method than the spitting method.

For the subsequent analysis, the calculated weight of the saliva was considered the SFR. The measured mg/2min were divided by two to assess the more common mg/min (Humphrey & Williamson, 2001). The first (baseline), and third (after stressor) SFR were used to calculate the change. The change in volume for each participant was calculated as follows: *Δ SFR (mg/min)* = SFR3 (mg/min) – SFR1 (mg/min). As a result, the outcome SFR is the delta between the third and first unstimulated, whole-mouth SFR.

**Data Analysis**

A significance level of $p < .05$, resp. a 95 % bootstrapping confidence interval (BCA CI) that did not include zero was set to determine whether the results significantly differed from those expected if the null hypothesis were correct. The data was analyzed using IBM® Statistics SPSS (Version 29.0.0.0) and Hayes PROCESS Macro© (Version 4.2; Hayes, 2017). The metric parameters mean value and standard deviation are used to describe general cohort characteristics.

To test all hypotheses, two mediation models were calculated using the Hayes PROCESS Macro© for SPSS (Version 4.2; Hayes, 2017). For the analysis of hypotheses 1.1, 1.2, 1.3, and 1.4 the first mediation model included Neuroticism (NEO-FFI-N sum score) as a predictor, subjective stress (*Δ* VAS*)* as the outcome and threat appraisal (PASA Threat sum score) as the possible mediator. For the analysis of hypotheses 2.1, 2.2, 2.3, and 2.4 the second mediation model included

Neuroticism (NEO-FFI-N sum score) as a predictor, salivary flow rate (*Δ* SFR*)* as the outcome and threat appraisal (PASA Threat sum score) as the possible mediator. Within the mediation models the path coefficient *c* represents H1.1 and H2.1 (total effect c), coefficient *a* H1.2 and H2.2 (condition a), coefficient *b* H1.3 and H2.3 (condition b), and *c'* H1.4 and H2.4 (indirect effect c'). The regression coefficient of the indirect effect represents its effect size and the BCA CI shows the statistical significance of the indirect effect.

The statistical assumptions of the mediation model include linearity, normal contribution of the residues, homoscedasticity, and independence of measures. According to Field (2018) mediation analysis with PROCESS® uses bootstrapping (resampling) and is therefore robust for distribution tributes. The factors should, however, show a linear relationship. The relationship of all variables involved in the mediation analysis was assessed by visual inspection of scatterplots and visual interpretation of the *locally weighted scatterplot smoothing* (LOESS).

**Missing data analysis and detection of outliers**

Data from participants that did not take part in the laboratory experiment were excluded for the analysis. Participants were not excluded for missing data points that resulted from a single questionnaire or measurement, and each case was handled individually. Moreover, Little's MCAR test (Little, 1988) was used to check if the data were missing completely at random. The MCAR analysis included the factors NEO-FFI-N sum score, *Δ* VAS, *Δ* SFR, and PASA Threat sum score. The result for the Little's MCAR test showed a non-significant $Chi^2$ statistic, indicating the data was missing completely at random with a *p* value > .05. Therefore, participants were only excluded if data necessary for the analysis was missing.

For all data sets, outliers were detected by inspection of boxplots displaying the interquartile range (IQR, $25^{th}$ to $75^{th}$ quartile). All data was, however, included for the data analysis after detailed inspection because the values were legitimate. Furthermore, an additional reduced statistical power due to the exclusion of cases showing legitimate exceptional values was aimed to be avoided.

# Results

## Sample characteristics

The final sample consisted of 45 female participants with a mean age of 24.49 (*SD* = 3.51), ranging between 18 to 33 years. Due to missing data points, several subjects had to be excluded for the two analyses. After the exclusion of the subjects with missing data points, a total of 41 subjects for the first and 42 subjects for the second model remained. Therefore, the required sample size of 59 participants, as indicated by the simulation results, could not be met. Table *2* depicts an overview of the cohorts' demographical characteristics. It is noticeable that the cohort is very homogenous considering school education. It is, however, more heterogenous in terms of nationality, housing, and relationship status. Moreover, all subjects have a normal BMI ranging between 19 and 30.

## Descriptive statistics

Table 3 presents an overview of the psychometric and biological factors used in the subsequent analyses. There is a slight reduction in the mean ΔSFR (*M* = -2.49) with a relatively high standard deviation (*SD* = 12.69) and range. This provides valuable information that the SFR values are very heterogenous for each subject. Moreover, there is, as expected, an increase in *Δ*VAS (*M* = 40.3, *SD* = 30.9) from the baseline to after the TSST. Additionally, the subjects show a mean NEO-FFI-N sum score of *M* = 20.3 (*SD* = 7.9). For comparison, Körner et al. (2008) found a mean neuroticism score of *M* = 21.1 in their validation study of the German NEO-FFI for women between 18 and 33 years.

**Table 2**

*Overview of the cohorts' demographic characteristics.*

| Demographic characteristic | M | SD | Range |
|---|---|---|---|
| Age in years | 24.49 | 3.51 | 18 - 33 |
| Height in cm | 167.45 | 6.06 | 154 - 178 |
| Weight in kg | 59.16 | 6.20 | 47 - 75 |
| | N | relative amount (%) | |
| Nationality | | | |
| Austria | 26 | 49.1 | |
| Germany | 7 | 13.2 | |
| Other | 10 | 37.6 | |
| School education | | | |
| A-levels | 41 | 91.1 | |
| Other | 4 | 8.8 | |
| Housing | | | |
| Alone | 9 | 20.0 | |
| Shared flat | 22 | 48.9 | |
| With partner | 8 | 17.8 | |
| Other | 6 | 13.3 | |
| Relationship status | | | |
| Single | 24 | 53.3 | |
| Partnership | 20 | 44.4 | |
| Other | 1 | 2.2 | |

*Note*: M = Mean, SD = Standard deviation, N = number of participants. Nationality "Other" includes Chile, France, Hong Kong, Italy, Columbia, Croatia, Swiss, Ukraine, and Hungary. School education "Other" includes secondary school levels and vocational high school as well as others. Housing "Other" includes with parents or family, a cat, mother, and sister. Relationship status "Other" includes open partnership.

**Table 3**

*Overview of the descriptive statistics for the psychometric as well as biological characteristics.*

| Psychometric charactersitics | M | SD | Range |
|---|---|---|---|
| Neuroticism | | | |
| NEO-FFI-N sum score | 20.31 | 7.93 | 4 - 35 |
| Threat appraisal | | | |
| PASA Threat sum score | 3.30 | 1.15 | 1 - 5 |
| Subjective stress | | | |
| VAS 1 | 12.56 | 13.48 | 0 - 57 |
| VAS 3 | 52.95 | 27.07 | 3 - 100 |
| Δ VAS | 40.34 | 30.91 | - 38 - 98 |
| Biological characteristic | | | |
| Salivary flow rate | | | |
| SFR 1 in mg/min | 23.28 | 15.88 | 4.05 - 92.60 |
| SFR 3 in mg/min | 20.79 | 16.72 | 1.10 - 72.85 |
| Δ SFR in mg/min | -2.49 | 12.69 | -27.30 - 33.75 |

*Note*: M = Mean, SD = Standard deviation, VAS = visual analogue scale of subjective stress, PASA = assessment of primary and secondary appraisal, SFR = salivary flow rate.

**Subjective stress response**

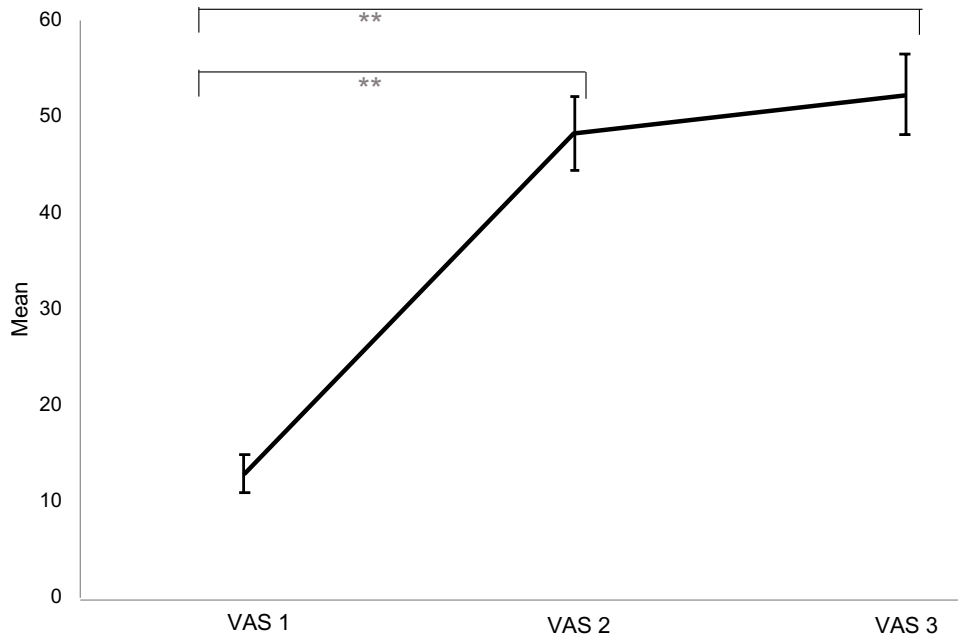
Before testing the first mediation model including N (NEO-FFI-N sum score) as the predictor, subjective stress as the outcome (*Δ*VAS), and threat appraisal (PASA Threat sum score) as the mediator, the linear relationship between the factors was assessed. The relationships were approximately linear after visually examining the

matrix scatterplots with LOESS smoothing. For the relationship between NEO-FFI-N sum score and *Δ*VAS, linearity can only be assumed conditionally because the scatterplot showed ambiguous results. A reduced power for hypothesis 1.1 must be assumed.

To exploratorily check if the TSST did induce an increase in subjective stress across all participants, a Friedman's ANOVA was calculated. The assumption of a repeated measure ANOVA could not be met, so the non-parametric Friedman's ANOVA was chosen for this analysis (Friedman, 1937). The results indicate a significant change of subjective stress for the participants over the first three measurements with $Chi^2(2) = 49.21$, $p = <.001$. Pairwise comparisons reveal a small, significant increase from the first measurement (VAS1) to the second (VAS2), $z = -1.17$, $p < .001$, $r = .17$ and from the first measurement to the third measurement (VAS3), $z = -1.41$, $p < .001$, $r = .21$. There was, however, no significant increase in subjective stress from the second to the third measurement, $z = -0.23$, $p = .843$, $r = .04$. Figure 4 presents a graphic illustration of the change in subjective stress over the first three measurements.

**Figure 4**

*The increase in subjective stress from the first measurement to the third measurement.*




*Note*. The error bars indicate one SD. VAS (subjective stress) represents subjective stress with a scale ranging from zero to 100; higher scores indicating higher subjective stress. The change in subjective stress from VAS1 to VAS2 is significant. The change in subjective stress from VAS1 to VAS3 is significant. VAS1 was measured upon arrival after the first set of questionnaires. VAS2 was measured after the instruction for the TSST and VAS3 was measured just after the TSST had been performed.

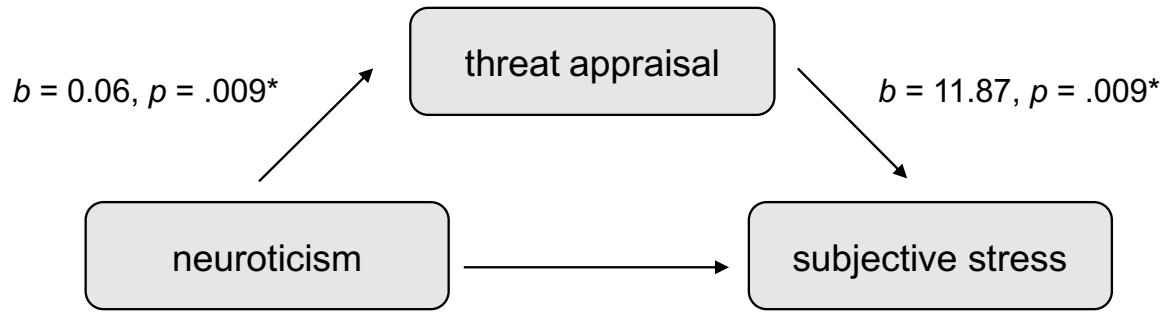
** = Significant increase with a *p*-value < .001.

For the first mediation model, data from 41 subjects were analyzed. The path coefficients of the mediation analysis revealed that N did not significantly predict subjective stress (total effect, H1.1) with $b = 0.32$, $p = .614$, but N did predict threat appraisal significantly (condition a, H1.2) with $b = 0.06$, $p < .05$. Threat appraisal predicted subjective stress significantly (condition b, H1.3) with $b = 11.87$, $p < .05$. Moreover, there was a significant indirect effect of N on subjective stress through threat appraisal (indirect effect c', H1.4), $b = 0.70$, 95 % BCa CI [0.12, 1.45] with a completely standardized effect of $b = .18$. Additionally, the results revealed a negative, non-significant direct effect of N on subjective stress with $b = -0.39$, $p =$

.547. The possibility of a suppression effect should be taken into account due to the presence of a negative, non-significant direct effect and a positive, significant indirect effect. According to MacKinnon et al. (2000) a suppression effect is considered as an inconsistent mediation model and therefore does not necessarily assume a significant relationship between predictor and outcome, as the mediation model does, to still be statistically valid. A suppression could be valid to interpret if a factor is expected to enhance an effect when included with another predictor. More precisely, if a suppression has occurred within this model, it suggests that threat appraisal enhances the association between N and subjective stress. This indicates interactions between N and threat appraisal that together explain more variance in the outcome stress, thus strengthening the association (visible in the indirect effect). To statistically test for suppression effects, however, the authors assume multivariate normal distribution of the factors as well as normally distributed error terms which cannot be assumed for the present data and therefore the test was not conducted for this analysis (MacKinnon et al., 2000). Figure 5 depicts the first mediation model with path coefficients.

**Figure 5**

*The first model with neuroticism as a predictor of subjective stress, mediated by threat appraisal.*




*Note*: The confidence interval for the indirect effect is a BCa bootstrapped CI based on 5000 samples.

* = Significant prediction of the factor with a *p*-value < .005.

The significant, positive indirect effect, non-significant, negative direct effect, and total effect (*b* = 0.32, *p* = .614) close to zero are considered indicative of a potential suppression effect.

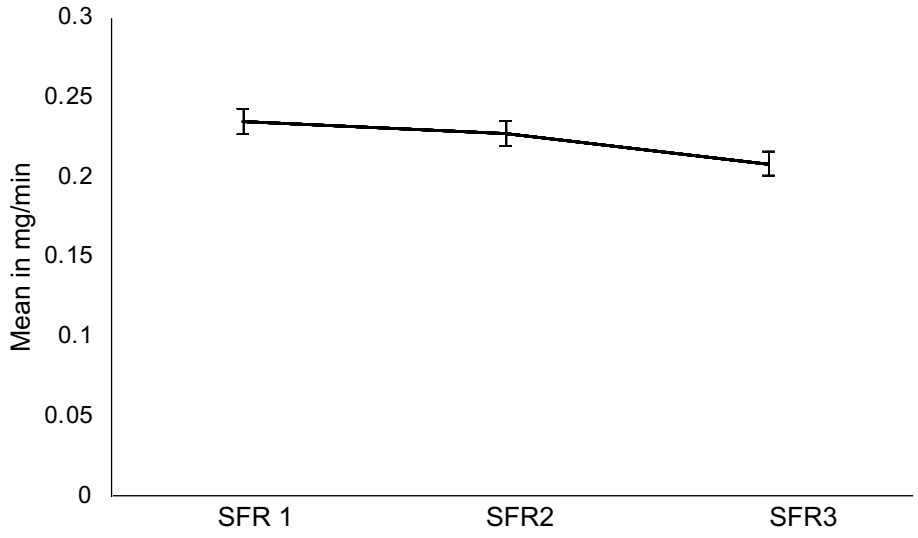
**Salivary flow rate**

Before testing the second mediation model, including N (NEO-FFI-N sum score) as the predictor, salivary flow rate as the outcome (*Δ*SFR), and threat appraisal (PASA Threat sum score) as the mediator, the linear relationship between the factors was assessed. The relationships were approximately linear after visually examining the matrix scatterplots with LOESS smoothing. Figure 6 depicts the change in SFR from the first, to the third measurement.

To exploratorily check if SFR significantly changed from baseline to after the TSST, a Friedman's ANOVA was calculated. The assumption of a repeated measure ANOVA could not be met, so the non-parametric Friedman's ANOVA was chosen for this analysis (Friedman, 1937). The results indicate a non- significant change of subjective stress for the participants over the first three measurements with $Chi^2(2) = 3.39$, $p = .185$.

**Figure 6**

*Change in salivary flow rate in mg/min from the first to the third measurement.*

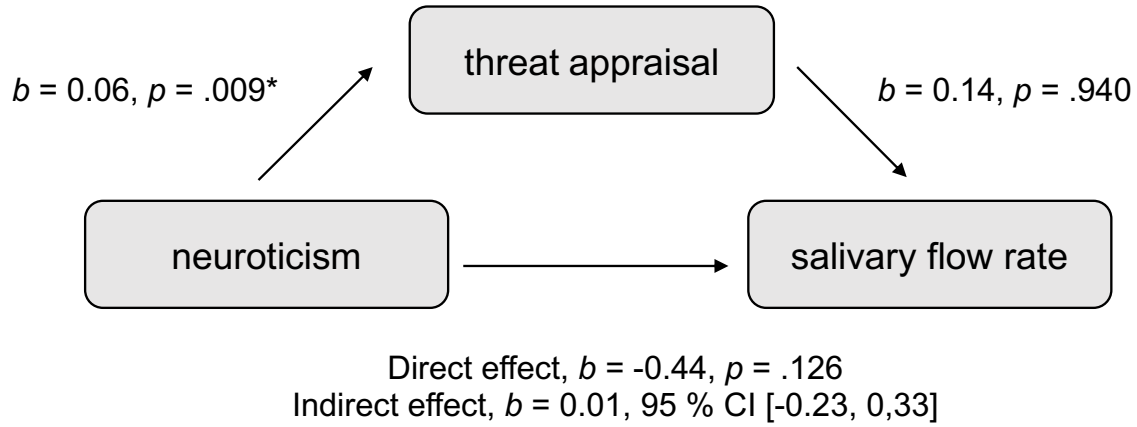



*Note*. The error bars indicate one SD. SFR1 was measured upon arrival after the first set of questionnaires. SFR2 was measured after the instruction for the TSST and SFR3 was measured just after the TSST had been performed.

For the second mediation model, data from 42 subjects was analyzed. The path coefficients of the mediation analysis revealed that N did not significantly predict salivary flow rate (total effect, H1.1) with $b$ = -0.43, $p$ = .101, but did predict threat appraisal significantly (condition a, H1.2) with $b$ = 0.06, $p$ < .05. Threat appraisal did not predict SFR significantly (condition b, H1.3) with $b$ = 0.14, $p$ = .940. Figure 7 shows the full mediation model.

**Figure 7**

*The second model of neuroticism as a predictor of salivary flow rate, mediated by threat appraisal.*




*Note*. The confidence interval for the indirect effect is a BCa bootstrapped CI based on 5000 samples.

* = Significant prediction of the factor with a $p$-value < .005.

## Discussion

This thesis aims to investigate if neuroticism positively predicts an increased stress reaction after an acute laboratory stressor and whether threat appraisal mediates that association. To differentiate between the subjective-, and physiological stress reaction, subjective stress as well as salivary flow rate are assessed and analyzed. Threat appraisal is analyzed as a possible mediator for the relationship between neuroticism and the stress response to further understand factors influencing an increased stress reactivity and vulnerability for people showing high expressions of N.

The expected association for H1.1 between N and subjective stress is that a higher expression of N would lead to an increased subjective stress reaction. This expectation is in line with previous findings postulating a particular reaction pattern following stressful situations for high-N individuals (Bibbey et al., 2013; Schneider, 2004; Schneider et al., 2012). Our results, however, show no significant association between N and subjective stress as indicated by a non-significant total effect of the first mediation model. However, we find N to positively predict threat appraisal (H1.2) and threat appraisal to predict subjective stress (H1.3) positively.

Furthermore, for H2.1 we hypothesized that N negatively predicts SFR with an increase in N leading to an enhanced decrease in SFR following the TSST. This expectation is based on the assumption that an increase in stress leads to a parasympathetic tonus on the salivary glands and therefore a decrease in SFR. In our experiments we find a slight, non-significant overall reduction in SFR right after the TSST compared to baseline. However, the second mediation model's total effect reveals no significant association between N and SFR (H2.1). Contrary to our expectations, threat appraisal does not significantly predict SFR (H2.3).

Moreover, the analysis of whether threat appraisal is a potential mediator between N and subjective stress yields inconclusive results (H1.4). The path analysis shows a positive, significant, indirect effect with a small completely standardized effect ($b$ = .18), but neither a significant direct, nor total effect. Lastly, there is no significant indirect effect for the second model with SFR as the outcome, suggesting no mediation occurred (H2.4).

**Neuroticism and threat appraisal**

In line with past research (Schneider et al., 2012), this analysis reveals N as a significant predictor for threat appraisal. The study conducted by Schneider et al. (2012) suggests that only N predicts higher threat appraisals when compared with the other Big Five traits. Since our analysis only focuses on N rather than all personality traits, a comparison of how strong a specific personality trait predicts threat appraisal compared to another is not possible. An exploratory correlation of E and N with threat appraisal reveals a medium, significant Spearman's rho for N correlated with threat appraisal ($\rho = .433$, $p = .004$ with $N = 42$) but a very small, non-significant correlation for E and threat appraisal ($\rho = .063$, $p = .712$ with $N = 37$). These correlations provide only limited interpretive power, but combined with the results from the mediation analysis they suggest a particularly important role of threat appraisal for N. Furthermore, our results help clarify the still relatively small and partly inconclusive body of studies on the influence of N on appraisals as a recent systematic review by Kilby et al. (2018) demonstrated.

There are different theories in the existing literature on how N and appraisal processes influence the exaggerated stress response that is often accompanied by negative affect. Our analysis is based on the model by Lazarus and Folkman (1984) that defines the primary appraisal as a crucial factor influencing the appraisal of coping strategies (secondary appraisal). Both factors then influence the stress reaction together since the appraisal of coping strategy is influenced by the appraisal of the situation. Other studies, however, propose personality traits influence a pattern of predisposed, learned information processing (Kilby et al., 2018). Accordingly, high-N individuals would mainly focus on threatening information in the environment, which would influence their perception altogether. By having a biased perception of the environment, high-N individuals would choose coping strategies aimed to avoid the stressful situation and thereby the emotional experience in the first place (Kilby et al., 2018). This theory is more in line with the diathesis model by Barlow et al. (2014) where N is a results of a very specific neurobiological model of information processing and a psychological predisposition that are both influenced by early life experiences. The model suggests that N results in a perceived uncontrollability and unpredictability of the stressor for high-N individuals and thus increasing the experience of stress. All models, however, revolve around construing a stressor or situation as threatening regardless of appraising it right after the onset or having a

biased perception. Moreover, the TSC does include a personal filter for perception which influences appraisals.

This work adds to the existing literature by showing that N positively predicts threat appraisal right before the stressor, and threat appraisal positively predicts subjective stress. Therefore our data support the model by Lazarus and Folkman (1984) that higher threat appraisal influences the degree of subjectively experienced stress.

**Neuroticism and subjective stress response**

Based on existing literature and the common conception that N leads to an increased stress susceptibility and stress response (Bibbey et al., 2013), we hypothesized that N positively predicts an increased subjective stress response after an active stress task (the TSST). As discussed above, we cannot find a positive association for N and subjective stress. This might be due to theoretical causes that will be elaborated more detailed below, however, the statistical relationship for the very association is only approximately linear, which could be one of the main reasons, why we cannot find this relationship. Additionally, the cohort is too small according to sample-size analysis, which leads to a reduced power for the mediation model. These two factors together provide sufficient reasons, why an existing effect could not be found. Nevertheless, there is also theoretical literature that supports the non-significant finding for N and subjective stress. Interestingly, a broader body of literature includes the negative affect as an outcome for high-N individuals experiencing stress, rather than investigating the subjective stress response itself.

Previous studies mostly show a positive association between N and increased negative affect in response to a stressor (Schneider, 2004; Verschoor & Markus, 2011; Xin et al., 2017). Interestingly, a study by Mroczek and Almeida (2004) postulates that N moderates the relationship between daily stress experience and daily negative affect with a steeper slope for the relationship in individuals with an increased expression of N. According to the authors, the increased negative affect of high-N individuals is partly due to the tendency to appraise a situation as threatening (Mroczek & Almeida, 2004; Suls & Martin, 2005). Threat carries a negative emotional value and therefore might influence the affect a person experiences during stressful encounters. In summary, the existing literature shows a consistent relationship for N and negative affect following a stressor (Schneider, 2004; Verschoor & Markus, 2011; Xin et al., 2017), but there is only a limited amount of research exploring and

reporting an increased subjective stress response following a laboratory stressor (Bibbey et al., 2013). This supports our non-significant findings for N and increased subjective stress.

Moreover, our data shows a significant, indirect effect for the first mediation model (see figure 5) with a negative, small direct effect. As mentioned above, this could be indicative of a suppression effect. There is a significant, positive association for N and threat appraisal as well as threat appraisal and subjective stress. These results highlight the mediating role of threat appraisal and were according to our expectation (Chu et al., 2022; Schneider, 2004) as well as the TSC as theoretical framework (Lazarus & Folkman, 1984). Furthermore, despite the non-significant direct relationship between N and subjective stress, the positive indirect effect is significant. Therefore, threat appraisal statistically attenuates the association between N and subjective stress to an extent that the effect is only present when threat appraisal is included into the model. This assumption is in line with the study by Mroczek and Almeida (2004), which shows N to moderate the relationship between daily stress experience and negative affect. Moreover, as discussed, threat appraisal might facilitate negative affect during the stress reaction (Mroczek & Almeida, 2004). Therefore, including threat appraisal into our mediation model would also include information about the experience of negative affect and thus would strengthen the relationship between N and subjective stress. The cause for that could be the experience of threat (with a strong negative emotional value) influences the negative affect and thus might explain why high-N individuals experience more distress. In the future, the possibility of a suppression model needs to be explored in detail, possibly including various factors into a multi-level analysis.

Another reason why there is no significant relationship between N and subjective stress might be its bidirectional causality, namely, that stressful experience increases the level of N, but also that N increases stressful experience. An idea from the diathesis model for N from Barlow et al. (2014) proposes that the reoccurring experience of distress (as explained by a neurobiological und psychological vulnerability) would lead to the expression of N, not the other way around. This is contrary to other conceptions of N, proposing N to be the cause of increased experience of distress (Gunthert et al., 1999). Both approaches combined might be indicative of a bidirectional relationship, which could explain why there is no unidirectional effect from N to subjective stress visible in our data.

Lastly, it is important to consider increased baseline levels of subjective stress for high-N individuals. Studied show that increases baseline HPA-levels influence the HPA-stress response to the extent that it is blunted (Kudielka et al., 2004; Oswald et al., 2006). Increased baseline subjective stress levels for high-N individuals could be a reason why there was no association between N and the subjective stress response after the TSST. Therefore, higher baseline subjective stress levels might have simply counteracted the expected (steeper) increase in subjective stress from baseline to after the TSST. To exploratorily check if N was associated with baseline subjective stress levels, a spearman's rho correlation for the two parameters was conducted retrospectively. Baseline subjective stress and N show, however, only weak, and non-significant association with $\rho = .21$, $p = 165$.

**SFR as stress marker**

Our results do not show a significant reduction or increase in SFR following the TSST. There is, however, a trend visible towards a slight reduction in SFR after the TSST (see figure 5). This finding is consistent with Nater et al. (2006) who show a slight, non-significant decrease in SFR during the TSST. There are several possible explanations for various findings on SFR and stress. Rohleder et al. (2006) propose that psychosocial stress leads to an increase in SFR, and physiological stressful activities tend to decrease the flow rate. In contrast to that, Gholami et al. (2017) found low unstimulated whole SFR to be associated with higher stress levels in students. However, in contrast to our study and the one by Nater et al. (2006), Gholami et al. (2017) did not induce acute stress but, rather evaluated the general stress level with a questionnaire. They then compared the individual general stress level with the SFR. One cause for the different findings could be that there are several different types of stressors used within all the studies. Used stressors range from academic stress (Bosch et al., 1996; Queiroz et al., 2002), neuropsychological tests such as the stroop test (Bakke et al., 2004) or memory-search test (Bosch et al., 2003; Nagy et al., 2015), stressful video watching (Bosch et al., 2003; Takai et al., 2004), cycling (Li & Gleeson, 2004), to the use of psychosocial tests such as the TSST (Nater et al., 2006). Moreover, the sampling methods differ in the literature as well (see table 1). Additionally, almost all studies on SFR and stress highlight various factors influencing the flow rate such as age, gender, medication, digestive issues and even time of the year (Bellagambi et al., 2020; Gholami et al., 2017; Humphrey & Williamson, 2001). These factors do not only make it difficult to compare the

individual studies, but also make it difficult to interpret the results obtained. Moreover, the conception of the sympathetic and parasympathetic nervous system as entirely exclusive mechanisms has recently been questioned. Thus, the validity to postulate an increase in the saliva amount to be mostly dependent on the parasympathetic becomes unclear (Rohleder et al., 2006). It is possible that the two systems complement each other in their functioning, rather that inhibit (Bosch et al., 2003; Rohleder et al., 2006).

For our study, it is unclear how much explanatory value can be found in the present data. The results from the Friedman's ANOVA show no significant reduction in SFR from baseline to right before and after the TSST. The slight, non-significant reduction in SFR does only indicate a decreasing trend and adds to the body of literature suggesting no significant change in SFR following the TSST.

## Limitations

There are different limitations to this study which might influence the results. Therefore, the interpretations need to be considered with great caution. The limitations regard the generalizability and validity of the obtained results.

### *Covid-19 pandemic*

Firstly, the data collection has started in the beginning of 2020 and the included data was collected until March 2023. This results in a three-year collection period, which poses several different challenges. In particular, the COVID-19 pandemic has led to changing conditions and opportunities for testing, resulting in different requirements for immunity and current COVID-test results. This led to interruptions and frequent changes of experimenter over the three years. More importantly, the pandemic posed tremendous changes in everyday life and the mental health of the population (Taylor et al., 2020). The experience of distress, anxiety and depressive symptoms accompanied the pandemic for many people, but especially students are viewed as high risk-group for adverse health outcomes. Other risk-factors for adverse mental health outcomes during the pandemic range from younger age, female gender, to having a higher education, and frequent consumption of media reports (Haas, 2020). Most of these factors could apply to our surveyed sample. An increased risk for the development of mental health problems might have led to exclusion of a greater number of participants. Moreover, this could have led to increased baseline stress levels. An additional limitation in this respect is that these

stress factors did not remain constant over the three years but possibly had different effects. Therefore, it remains unclear how a possible change in the individual stress level due to COVID could have influenced the effectiveness of the stress induction.

***Sample characteristics, generalizability, and validity***

Secondly, the data we collected stems from a very homogenous cohort considering factors such as age, education or mental- and general health. While we did not exclude any specific groups of different educational backgrounds, recruitment platforms might have led to the participants being mainly students. Especially the very high education level within our sample – which might also be influenced by the high demand regarding the German language level – possibly led to an underrepresentation of specific groups in Austria. Moreover, the exclusion from the study of individuals with mental health issues might have led to distorted sample characteristics considering N, since N is closely related to various adverse mental health outcomes (Lahey, 2009). Generally, current mental disorders seem to be rising worldwide (Haas, 2020) which shows that a large part of individuals would have been excluded. This exclusion criteria could have excluded many applicants for the study that showed increased N levels. Therefore, our sample might be rather homogenous considering N-expression and thus detecting an effect in the outcomes with N as a predictor could become difficult.

Another factor besides the generalizability of the sample is that the analyzed sample size was too small to detect a possible effect with a power of 80 %. This leads to the danger of identifying false negative or false positive results and thereby a wrong interpretation. Moreover, it could be an explanation for the unique pattern of the first mediation model.

Another important limitation is the violation of the statistical assumption of linearity for the mediation mode. While mediation analysis uses bootstrapping and thus is mostly robust for sample statistical characteristics, the variables included need to show a linear relationship (Field, 2018). Unfortunately, the predictor variable (N) and outcome variable (subjective stress response) only showed an approximate linear relationship which leads to indecisive interpretational power. In addition to that, the reported results concerning subjective stress, threat appraisal, and N are based on self-reported measures. This could be associated with biases and further research should include another physiological stress marker that has been shown to

reliably represent the stress reaction, like salivary cortisol (Hellhammer et al., 2009) or heart rate variability (Kim et al., 2018).

## Implications

The analysis within this master thesis shows mixed results regarding the association between the personality factor neuroticism and stress indices. The results need to be interpreted with caution, but still add to existing literature. Especially the relationship between N and subjective stress needs to be further investigated while possibly including negative affect, to gain a deeper understanding of the corresponding action mechanisms. For this, it might be helpful to allow broader samples, being more heterogenous regarding mental health to possibly allow for more variance in the expressions of N.

Moreover, to assess SFR as a stress index, more specified research with similar stress tasks and measurements needs to be conducted to provide a generalizable statement about how the salvation reacts to acute stress.

Regardless of the named limitations, this study helps to clarify that N is associated with threat appraisal. In future that could help developing and applying therapeutical interventions concerning stress or the reduction of perceptional biases for individuals with a higher N expression. Offering specific interventions targeting threat appraisal could be beneficial for high-N individuals (Britton et al., 2011; Smits et al., 2012).

## Conclusion

In order to mitigate the enormous impact that stress has on adverse health outcomes worldwide, there is the need to investigate stress and its association with mental as well as physiological disorders and the urgency to understand the mechanisms through which stress operates in individuals. Moreover, stress markers that are easy to assess (e.g., SFR) are needed to simplify stress research. We addressed the research questions what the effect of neuroticism on the change in subjective stress, resp. SFR after a laboratory stress task is. Moreover, we analyzed if a possible effect of neuroticism on subjective stress, resp. salivary flow rate is mediated by threat appraisal. The analysis was part of a broader laboratory experiment that assessed the effects of acute stress on skin barrier recovery. Therefore, the participants had to perform a social stress task (TSST) to compare baseline values with measurements right after the TSST and the recovery. This study provides valuable information

regarding the generalized tendency of individuals showing high expressions of N to appraise situations as threatening. Moreover, the results add to existing literature by confirming that threat appraisal predicts an increase in the subjective stress reaction. However, our results show that N did not significantly predict an increased subjective stress response after the TSST. However, when the mediator threat appraisal is included into the model, there is a significant, positive association between N and subjective stress. All three results need to be evaluated with caution due to several statistical limitations. Moreover, N did also not significantly predict an enhanced reduction in SFR after the TSST. There was no significant mediation by threat appraisal for the association between N and SFR. However, SFR did not significantly change in response to the TSST – making it hard to find effects in the mediation model.

The presented results pose the question why the relationship between N and subjective stress might only become visible when threat appraisal is included. Further research including negative affect in potential multi-level analyses needs to be conducted to understand the exact mechanisms of action, possibly including secondary appraisals (coping strategies) to gain a broader picture. Additionally, this master thesis helps to understand if SFR is a promising stress marker. The analysis regarding the change in SFR following the TSST suggests no clear detectable change in the flow rate.

## References

Allen, A. P., Kennedy, P. J., Cryan, J. F., Dinan, T. G., & Clarke, G. (2014). Biological and psychological markers of stress in humans: Focus on the Trier Social Stress Test. *Neuroscience & Biobehavioral Reviews*, *38*, 94-124. https://doi.org/https://doi.org/10.1016/j.neubiorev.2013.11.005

Bakke, M., Tuxen, A., Thomsen, C. E., Bardow, A., Alkjaer, T., & Jensen, B. R. (2004). Salivary cortisol level, salivary flow rate, and masticatory muscle activity in response to acute mental stress: a comparison between aged and young women. *Gerontology*, *50*(6), 383-392. https://doi.org/10.1159/000080176

Barlow, D. H., Ellard, K. K., Sauer-Zavala, S., Bullis, J. R., & Carl, J. R. (2014). The origins of neuroticism. *Perspectives on Psychological Science*, *9*(5), 481-496. https://doi.org/10.1177/1745691614544528

Bear, M., Connors, B., & Paradiso, M. A. (2020). *Neuroscience: Exploring the Brain, Enhanced Edition: Exploring the Brain*. Jones & Bartlett Learning.

Beck, A. T., Steer, R. A., & Brown, G. (1996). *Beck depression inventory–II*. https://doi.org/10.1037/t00742-000

Bellagambi, F. G., Lomonaco, T., Salvo, P., Vivaldi, F., Hangouët, M., Ghimenti, S., Biagini, D., Di Francesco, F., Fuoco, R., & Errachid, A. (2020). Saliva sampling: Methods and devices. An overview. *TrAC Trends in Analytical Chemistry*, *124*, 115781. https://doi.org/https://doi.org/10.1016/j.trac.2019.115781

Bernstein, D. P., Fink, L., Handelsman, L., Foote, J., Lovejoy, M., Wenzel, K., Sapareto, E., & Ruggiero, J. (1994). Initial reliability and validity of a new retrospective measure of child abuse and neglect. *The American Journal of Psychiatry*, *151*(8), 1132-1136. https://doi.org/10.1176/ajp.151.8.1132

Bibbey, A., Carroll, D., Roseboom, T. J., Phillips, A. C., & de Rooij, S. R. (2013). Personality and physiological reactions to acute psychological stress. *International Journal of Psychophysiology*, *90*(1), 28-36. https://doi.org/10.1016/j.ijpsycho.2012.10.018

Borkenau, P., & Ostendorf, F. (1993). *NEO-Fünf-Faktoren-Inventar (NEO-FFI) nach Costa und McCrae (1. Aufl.)*. Hogrefe.

Bosch, J. A., Brand, H. S., Ligtenberg, T. J., Bermond, B., Hoogstraten, J., & Amerongen, A. V. N. (1996). Psychological stress as a determinant of protein levels and salivary-induced aggregation of Streptococcus gordonii in human whole saliva. *Psychosomatic Medicine*, *58*(4), 374-382. https://doi.org/10.1097/00006842-199607000-00010

Bosch, J. A., de Geus, E. J., Veerman, E. C., Hoogstraten, J., & Amerongen, A. V. N. (2003). Innate secretory immunity in response to laboratory stressors that evoke distinct patterns of cardiac autonomic activity. *Psychosomatic Medicine*, *65*(2), 245-258. https://doi.org/10.1097/01.psy.0000058376.50240.2d

Brinkmann, R. (2021). *Angewandte Gesundheitspsychologie (2., aktualisierte Auflage)*. Pearson.

Britton, J. C., Lissek, S., Grillon, C., Norcross, M. A., & Pine, D. S. (2011). Development of anxiety: the role of threat appraisal and fear learning. *Depression and Anxiety 28*(1), 5-17. https://doi.org/10.1002/da.20733

Carver, C. S. (1997). You want to measure coping but your protocol' too long: Consider the brief cope. *International Journal of Behavioral Medicine*, *4*(1), 92-100. https://doi.org/10.1207/s15327558ijbm0401_6

Chu, G. M., Goger, P., Malaktaris, A., & Lang, A. J. (2022). The role of threat appraisal and coping style in psychological response to the COVID-19 pandemic among university students. *Journal of Affective Disorders Reports*, *8*, 100325. https://doi.org/https://doi.org/10.1016/j.jadr.2022.100325

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A Global Measure of Perceived Stress. *Journal of Health and Social Behavior*, *24*(4), 385-396. https://doi.org/10.2307/2136404

Costa, P. T., & McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five Factory Inventory (NEO-FFI). Professional manual.* Psychological Assessment Resources.

DeLongis, A., Folkman, S., & Lazarus, R. S. (1988). The impact of daily stress on health and mood: psychological and social resources as mediators. *Journal of Personality and Social Psychology*, *54*(3), 486. https://doi.org/10.1037/0022-3514.54.3.486

Diener, E., & Lucas, R. E. (2019). Personality traits. In R. Biswas-Diener & E. Diener (Eds.), *General psychology: Required reading*. Noba.

Dugdale, J. R., Eklund, R. C., & Gordon, S. (2002). Expected and unexpected stressors in major international competition: Appraisal, coping, and performance. *The Sport Psychologist*, *16*(1), 20-33. https://doi.org/doi.org/10.1123/tsp.16.1.20

Feher, J. (2012). 4.9 - Autonomic Nervous System. In J. Feher (Ed.), *Quantitative Human Physiology* (pp. 403-416). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-382163-8.00043-8

Feher, J. (2017). 8.1 - Mouth and Esophagus. In J. Feher (Ed.), *Quantitative Human Physiology (Second Edition)* (pp. 771-784). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-800883-6.00077-X

Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics (5th edition)*. Sage.

Folkman, S., Lazarus, R. S., Dunkel-Schetter, C., DeLongis, A., & Gruen, R. J. (1986). Dynamics of a stressful encounter: cognitive appraisal, coping, and encounter outcomes. *Journal of Personality and Social Psychology*, *50*(5), 992. https://doi.org/10.1037/0022-3514.50.5.992

Franks, H. M., & Roesch, S. C. (2006). Appraisals and coping in people living with cancer: a meta-analysis. *Psycho-Oncology*, *15*(12), 1027-1037. https://doi.org/10.1002/pon.1043

Friedman, M. (1937). The Use of Ranks to Avoid the Assumption of Normality Implicit in the Analysis of Variance. *Journal of the American Statistical Association*, *32*(200), 675-701. https://doi.org/10.1080/01621459.1937.10503522

Fritz, M. S., & Mackinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological science*, *18*(3), 233-239. https://doi.org/10.1111/j.1467-9280.2007.01882.x

Gaab, J. (2008). PASA - Primary Appraisal Secondary Appraisal. Ein Fragebogen zur Erfassung von situationsbezogenen kognitiven Bewertungen. *Verhaltenstherapie*, *19*, 114-115. https://doi.org/10.1159/000223610

Gaab, J., Rohleder, N., Nater, U. M., & Ehlert, U. (2005). Psychological determinants of the cortisol stress response: the role of anticipatory cognitive appraisal.

*Psychoneuroendocrinology*, *30*(6), 599-610. https://doi.org/10.1016/j.psyneuen.2005.02.001

Gholami, N., Hosseini Sabzvari, B., Razzaghi, A., & Salah, S. (2017). Effect of stress, anxiety and depression on unstimulated salivary flow rate and xerostomia. *Journal of Dental Research, Sental Clinics, Dental Prospects*, *11*(4), 247-252. https://doi.org/10.15171/joddd.2017.043

Goldberg, L. R. (1990). An alternative" description of personality": the big-five factor structure. *Journal of Personality and Social Psychology*, *59*(6), 1216. https://doi.org/10.1037/0022-3514.59.6.1216

Gräfe, K., Zipfel, S., Herzog, W., & Löwe, B. (2004). Screening psychischer Störungen mit dem “Gesundheitsfragebogen für Patienten (PHQ-D)“. *Diagnostica*, *50*(4), 171-181. https://doi.org/10.1026/0012-1924.50.4.171

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348. https://doi.org/10.1037/0022-3514.85.2.348

Gunthert, K. C., Cohen, L. H., & Armeli, S. (1999). The role of neuroticism in daily stress and coping. *Journal of Personality and Social Psychology*, *77*(5), 1087. https://doi.org/10.1037/0022-3514.77.5.1087

Haas, J. G. (2020). Die COVID-19 Pandemie und die menschliche Psyche. In J. G. Haas (Ed.), *COVID-19 und Psychologie: Mensch und Gesellschaft in Zeiten der Pandemie* (pp. 27-35). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-32031-7_5

Hayes, A. F. (2017). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach (2nd ed.).* The Guilford Press.

Hellhammer, D. H., Wüst, S., & Kudielka, B. M. (2009). Salivary cortisol as a biomarker in stress research. *Psychoneuroendocrinology*, *34*(2), 163-171. https://doi.org/https://doi.org/10.1016/j.psyneuen.2008.10.026

Holmes, T. H., & Rahe, R. H. (1967). The social readjustment rating scale. *Journal of Psychosomatic Research*, *11*(2), 213-218. https://doi.org/doi.org/10.1016/0022-3999(67)90010-4

Humphrey, S. P., & Williamson, R. T. (2001). A review of saliva: normal composition, flow, and function. *The Journal of Prosthetic Dentistry*, *85*(2), 162-169. https://doi.org/10.1067/mpr.2001.113778

Hutchinson, J. G., & Williams, P. G. (2007). Neuroticism, daily hassles, and depressive symptoms: An examination of moderating and mediating effects. *Personality and Individual Differences*, *42*(7), 1367-1378. https://doi.org/10.1016/j.paid.2006.10.014

Inoue, H., Ono, K., Masuda, W., Morimoto, Y., Tanaka, T., Yokota, M., & Inenaga, K. (2006). Gender difference in unstimulated whole saliva flow rate and salivary gland sizes. *Archives of Oral Biology*, *51*(12), 1055-1060. https://doi.org/10.1016/j.archoralbio.2006.06.010

Kanning, U. P. (2009). NEO-Fünf-Faktoren-Inventar nach Costa und McCrae (NEO-FFI). *Zeitschrift für Arbeits- und Organisationspsychologie A&O*, *53*(4), 194-198. https://doi.org/10.1026/0932-4089.53.4.194

Kemeny, M. E. (2003). The Psychobiology of Stress. *Current Directions in Psychological Science*, *12*(4), 124-129. https://doi.org/10.1111/1467-8721.01246

Kendler, K. S., Kuhn, J., & Prescott, C. A. (2004). The interrelationship of neuroticism, sex, and stressful life events in the prediction of episodes of major depression. *American Journal of Psychiatry*, *161*(4), 631-636. https://doi.org/10.1176/appi.ajp.161.4.631

Kilby, C. J., & Sherman, K. A. (2016). Delineating the relationship between stress mindset and primary appraisals: preliminary findings. *SpringerPlus*, *5*(1), 336. https://doi.org/10.1186/s40064-016-1937-7

Kilby, C. J., Sherman, K. A., & Wuthrich, V. (2018). Towards understanding interindividual differences in stressor appraisals: A systematic review. *Personality and Individual Differences*, *135*, 92-100. https://doi.org/https://doi.org/10.1016/j.paid.2018.07.001

Kim, H. G., Cheon, E. J., Bai, D. S., Lee, Y. H., & Koo, B. H. (2018). Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature. *Psychiatry Investig*, *15*(3), 235-245. https://doi.org/10.30773/pi.2017.08.17

Kirschbaum, C., Pirke, K.-M., & Hellhammer, D. H. (1993). The 'Trier Social Stress Test'–a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*(1-2), 76-81. https://doi.org/10.1159/000119004

Knappe, S., & Hoyer, J. (2020). *Klinische Psychologie & Psychotherapie* (3., vollst. überarb. Aufl. 2020 ed.). Springer. https://doi.org/10.1007/978-3-662-61814-1

Körner, A., Drapeau, M., Albani, C., Geyer, M., Schmutzer, G., & Brähler, E. (2008). Deutsche Normierung des NEO-Fünf-Faktoren-Inventars (NEO-FFI) [German norms for the NEO Five-Factor Inventory]. *Zeitschrift für Medizinische Psychologie*, *17*, 133-144.

Kudielka, B. M., Schommer, N. C., Hellhammer, D. H., & Kirschbaum, C. (2004). Acute HPA axis responses, heart rate, and mood changes to psychosocial stress (TSST) in humans at different times of day. *Psychoneuroendocrinology*, *29*(8), 983-992. https://doi.org/10.1016/j.psyneuen.2003.08.009

Kues, J. N., Janda, C., Kleinstäuber, M., & Weise, C. (2016). How to measure the impact of premenstrual symptoms? Development and validation of the German PMS-Impact Questionnaire. *Women & Health*, *56*(7), 807-826. https://doi.org/10.1080/03630242.2015.1118734

Lahey, B. B. (2009). Public health significance of neuroticism. *The American Psychologist*, *64*(4), 241-256. https://doi.org/10.1037/a0015309

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. Springer publishing company.

Lesage, F.-X., Berjot, S., & Deschamps, F. (2012). Clinical stress assessment using a visual analogue scale. *Occupational Medicine*, *62*(8), 600-605. https://doi.org/10.1093/occmed/kqs140

Li, T., & Gleeson, M. (2004). The effect of single and repeated bouts of prolonged cycling and circadian variation on saliva flow rate, immunoglobulin A and-amylase responses. *Journal of Sports Sciences*, *22*(11-12), 1015-1024. https://doi.org/10.1080/02640410410001716733

Linnemann, A., Kreutz, G., Gollwitzer, M., & Nater, U. (2018). Validation of the German Version of the Music-Empathizing-Music-Systemizing (MEMS)

Inventory (Short Version). *Frontiers in Behavioral Neuroscience*, *12*, 153. https://doi.org/10.3389/fnbeh.2018.00153

Little, R. J. A. (1988). A Test of Missing Completely at Random for Multivariate Data with Missing Values. *Journal of the American Statistical Association*, *83*(404), 1198-1202. https://doi.org/10.1080/01621459.1988.10478722

Lovallo, W. R. (2015). *Stress and health: Biological and psychological interactions*. Sage publications.

MacKinnon, D. P., Krull, J. L., & Lockwood, C. M. (2000). Equivalence of the Mediation, Confounding and Suppression Effect. *Prevention Science*, *1*(4), 173-181. https://doi.org/10.1023/A:1026595011371

Matthews, G., Deary, I. J., & Whiteman, M. C. (2003). *Personality traits (2nd ed.)*. Cambridge University Press. https://doi.org/10.1017/CBO9780511812736

McCarty, R. (2016). Chapter 4 - The Fight-or-Flight Response: A Cornerstone of Stress Research. In G. Fink (Ed.), *Stress: Concepts, Cognition, Emotion, and Behavior* (pp. 33-37). Academic Press. https://doi.org/10.1016/B978-0-12-800951-2.00004-2

McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York Academy of Sciences*, *840*(1), 33-44. https://doi.org/10.1111/j.1749-6632.1998.tb09546.x

Mroczek, D. K., & Almeida, D. M. (2004). The effect of daily stress, personality, and age on daily negative affect. *Journal of personality*, *72*(2), 355-378. https://doi.org/10.1111/j.0022-3506.2004.00265.x

Müllensiefen, D., Gingras, B., Musil, J., & Stewart, L. (2014). The musicality of non-musicians: An index for assessing musical sophistication in the general population. *PLOS ONE*, *9*(2), e89642. https://doi.org/10.1371/journal.pone.0089642

Nagy, T., Van Lién, R., Willemsen, G., Proctor, G., Efting, M., Fülöp, M., Bárdos, G., Veerman, E. C., & Bosch, J. A. (2015). A fluid response: Alpha-amylase reactions to acute laboratory stress are related to sample timing and saliva flow rate. *Biological Psychology*, *109*, 111-119. https://doi.org/10.1016/j.biopsycho.2015.04.012

Nater, U. M., Krebs, M., & Ehlert, U. (2005). Sensation Seeking, Music Preference, and Psychophysiological Reactivity to Music. *Musicae Scientiae*, *9*(2), 239-254. https://doi.org/10.1177/102986490500900205

Nater, U. M., La Marca, R., Florin, L., Moses, A., Langhans, W., Koller, M. M., & Ehlert, U. (2006). Stress-induced changes in human salivary alpha-amylase activity—associations with adrenergic activity. *Psychoneuroendocrinology*, *31*(1), 49-58. https://doi.org/10.1016/j.psyneuen.2005.05.010

Ormel, J., Bastiaansen, A., Riese, H., Bos, E. H., Servaas, M., Ellenbogen, M., Rosmalen, J. G., & Aleman, A. (2013). The biological and psychological basis of neuroticism: current status and future directions. *Neuroscience & Biobehavioral Reviews*, *37*(1), 59-72. https://doi.org/10.1016/j.neubiorev.2012.09.004

Oswald, L. M., Zandi, P., Nestadt, G., Potash, J. B., Kalaydjian, A. E., & Wand, G. S. (2006). Relationship between Cortisol Responses to Stress and Personality. *Neuropsychopharmacology*, *31*(7), 1583-1591. https://doi.org/10.1038/sj.npp.1301012

Pedersen, A., Sørensen, C., Proctor, G., Carpenter, G., & Ekström, J. (2018). Salivary secretion in health and disease. *Journal of Oral Rehabilitation*, *45*(9), 730-746. https://doi.org/10.1111/joor.12664

Proctor, G. B., & Carpenter, G. H. (2014). Salivary secretion: mechanism and neural regulation. *Monographs in Oral Science*, *24*, 14-29. https://doi.org/10.1159/000358781

Puig-Perez, S., Villada, C., Pulopulos, M. M., Hidalgo, V., & Salvador, A. (2016). How are neuroticism and depression related to the psychophysiological stress response to acute stress in healthy older people? *Physiology & Behavior*, *156*, 128-136. https://doi.org/https://doi.org/10.1016/j.physbeh.2016.01.015

Queiroz, C. S., Hayacibara, M. F., Tabchoury, C. P. M., Marcondes, F. K., & Cury, J. A. (2002). Relationship between stressful situations, salivary flow rate and oral volatile sulfur-containing compounds. *European Journal of Oral Sciences*, *110*(5), 337-340. https://doi.org/10.1034/j.1600-0722.2002.21320.x

Rohleder, N., Wolf, J. M., Maldonado, E. F., & Kirschbaum, C. (2006). The psychosocial stress-induced increase in salivary alpha-amylase is

independent of saliva flow rate. *Psychophysiology*, *43*(6), 645-652. https://doi.org/10.1111/j.1469-8986.2006.00457.x

Rosenberg, M. (1965). Rosenberg self-esteem scale. *Journal of Religion and Health*. https://doi.org/10.1037/t01038-000

Saarikallio, S. (2012). Development and validation of the brief music in mood regulation scale (B-MMR). *Music Perception: an Interdisciplinary Journal*, *30*(1), 97-105. https://doi.org/10.1525/mp.2012.30.1.97

Schneider, T. R. (2004). The role of neuroticism on psychological and physiological stress responses. *Journal of Experimental Social Psychology*, *40*(6), 795-804. https://doi.org/10.1016/j.jesp.2004.04.005

Schneider, T. R. (2008). Evaluations of stressful transactions: what's in an appraisal? *Stress and Health: Journal of the International Society for the Investigation of Stress*, *24*(2), 151-158. https://doi.org/10.1002/smi.1176

Schneider, T. R., Rench, T. A., Lyons, J. B., & Riffle, R. R. (2012). The Influence of Neuroticism, Extraversion and Openness on Stress Responses. *Stress and Health*, *28*(2), 102-110. https://doi.org/10.1002/smi.1409

Schneiderman, N., Ironson, G., & Siegel, S. D. (2005). Stress and health: psychological, behavioral, and biological determinants. *Annual Review of Clinical Psychology*, *1*, 607-628. https://doi.org/10.1146/annurev.clinpsy.1.102803.144141

Schulz, P., Jansen, L. J., & Schlotz, W. (2005). Stressreaktivität: theoretisches konzept und messung. *Diagnostica*, *51*(3), 124-133. https://doi.org/10.1026/0012-1924.51.3.124

Schulz, P., & Schlotz, W. (1999). Trierer Inventar zur Erfassung von chronischem Stress (TICS): Skalenkonstruktion, teststatistische Überprüfung und Validierung der Skala Arbeitsüberlastung. *Diagnostica*. https://doi.org/10.1026/0012-1924.45.1.8

Schumacher, J., Leppert, K., Gunzelmann, T., Strauss, B., & Brähler, E. (2005). Die Resilienzskala - Ein Fragebogen zur Erfassung der psychischen Widerstandfähigkeit als Personmerkmal. *Zeitschrift für Klinische Psychologie, Psychiatrie und Psychotherapie*, *53*, 16-39.

Selye, H. (1976). *Stress in health and disease*. Butterworth-Heinemann.

Smith, C. A., & Lazarus, R. S. (1990). Emotion and adaptation. *Handbook of Personality: Theory and Research*, *21*, 609-637. https://doi.org/10.2307/2075902

Smits, J. A., Julian, K., Rosenfield, D., & Powers, M. B. (2012). Threat reappraisal as a mediator of symptom change in cognitive-behavioral treatment of anxiety disorders: a systematic review. *Journal of Consulting and Clinical Psychology*, *80*(4), 624. https://doi.org/10.1037/a0028957

Spielberger, C. D., Laux, L., Glanzmann, P., & Schaffner, P. (1981). *Das State-Trait-Angstinventar (STAI): theoretische Grundlagen und Handanweisung*. Beltz Testgesellschaft.

Sterling, P., & Eyer, J. (1988). Allostasis: A new paradigm to explain arousal pathology. In S. Fisher & J. Reason (Eds.), *Handbook of life stress, cognition and health.* (pp. 629-649). John Wiley & Sons.

Steyer, R., Schwenkmezger, P., Notz, P., & Eid, M. (1994). Testtheoretische Analysen des Mehrdimensionalen Befindlichkeitsfragebogen (MDBF). [Theoretical analysis of a multidimensional mood questionnaire (MDBF).]. *Diagnostica*, *40*, 320-328.

Suls, J., & Martin, R. (2005). The daily life of the garden-variety neurotic: Reactivity, stressor exposure, mood spillover, and maladaptive coping. *Journal of Personality*, *73*(6), 1485-1510. https://doi.org/10.1111/j.1467-6494.2005.00356.x

Takai, N., Yamaguchi, M., Aragaki, T., Eto, K., Uchihashi, K., & Nishikawa, Y. (2004). Effect of psychological stress on the salivary cortisol and amylase levels in healthy young adults. *Archives of Oral Biology*, *49*(12), 963-968. https://doi.org/10.1016/j.archoralbio.2004.06.007

Taylor, S., Landry, C. A., Paluszek, M. M., Fergus, T. A., McKay, D., & Asmundson, G. J. G. (2020). COVID stress syndrome: Concept, structure, and correlates. *Depression and Anxiety*, *37*(8), 706-714. https://doi.org/https://doi.org/10.1002/da.23071

Tellegen, A., & Atkinson, G. (1981). Tellegen absorption scale. *Journal of Abnormal Psychology*. https://doi.org/10.1037/t14465-000

Tomaka, J., & Magoc, D. (2021). Personality antecedents of challenge and threat appraisal. *Stress and Health*, *37*(4), 682-691. https://doi.org/10.1002/smi.3028

Verschoor, E., & Markus, C. R. (2011). Effects of acute psychosocial stress exposure on endocrine and affective reactivity in college students differing in the 5-HTTLPR genotype and trait neuroticism. *Stress*, *14*(4), 407-419. https://doi.org/10.3109/10253890.2010.548886

Westenberger, A., Nöhre, M., Brähler, E., Morfeld, M., & de Zwaan, M. (2022). Psychometric properties, factor structure, and German population norms of the multidimensional fatigue inventory (MFI-20). *Front Psychiatry*, *13*, 1062426. https://doi.org/10.3389/fpsyt.2022.1062426

Xin, Y., Wu, J., Yao, Z., Guan, Q., Aleman, A., & Luo, Y. (2017). The relationship between personality and the response to acute psychological stress. *Scientific Reports*, *7*(1), 1-8. https://doi.org/10.1038/s41598-017-17053-2

## List of Figures and Tables

### Figures



### Tables

## List of Abbreviations

| | |
|---|---|
| A: | Agreeableness |
| ACTH: | Adrenocorticotropic hormone |
| ANOVA: | Analysis of Variance |
| ANS: | Autonomic nervous system |
| BCA CI: | Bias-corrected and accelerated confidence intervals |
| BDI-II: | Beck's Depression Inventory |
| BMI: | Body Mass Index |
| B-MMR: | Brief Music in Mood Regulation Scale |
| C: | Conscientiousness |
| CI's: | Confidence Intervals |
| CRH: | Corticotropin-releasing hormone |
| CTQ: | Childhood Trauma Questionnaire |
| E: | Extraversion |
| ERQ: | Emotion Regulation Questionnaire |
| G.A.S.: | General Adaption Syndrome |
| G-MSI: | Gold-MSI |
| HPA axis: | Hypothalamic–Pituitary–Adrenal axis |
| LOESS: | Locally weighted scatterplot smoothing |
| M: | Mean |
| MBDF: | Mehrdimensionaler Befindlichkeitsfragebogen |
| MEMS: | Music-Empathizing-Music-Systemizing Inventory |
| MFI-20: | Multidimensional Fatigue Inventory |
| MPQ: | Music Preference Questionnaire |
| N: | Neuroticism |
| NEO-FFI: | NEO-Five-Factor-Inventory |
| O: | Openness to experience |
| PASA: | Primary Appraisal Secondary Appraisal |
| PHQ-D: | Prime MD Patient Health Questionnaire |
| PMS_I: | Premenstrual Syndrome Impact Questionnaire |
| PSRS: | Perceived Stress Reactivity Scale |
| PSS: | Perceived Stress Scale |

| | |
|---|---|
| RSES: | Rosenberg Self Esteem Scale |
| SD: | Standard Deviation |
| SFR: | Salivary flow rate |
| STAI-S: | State-Trait Anxiety Scale, Form S |
| STAI-T: | State Trait Anxiety Scale, Form T |
| TABS: | Tellegen Absorption Scale |
| TEWL: | Transepidermal water loss |
| TICS: | Trier Inventar zum chronischen Stress |
| TSC: | Transactional Model of Stress and Coping |
| TSST: | Trier Social Stress Test |
| TTPAS: | Types of positive Affect Scale |
| UWSFR: | Unstimulated whole salivary flow rate |
| VAS: | Visual analogue scale |

## Appendix

### Abstract (English)

Neuroticism along with the prolonged experience of stress are commonly known risk factors for the development of mental disorders. Moreover, the negative response towards stressful events increases with higher expression of neuroticism. Therefore, it is important to understand mechanism that underlie this vulnerability towards stress. Furthermore, it is still debated if individuals with a high neuroticism expression show an enhanced subjective stress response. This study investigated the role of threat appraisals in the subjective stress reaction in association with neuroticism with 42 female participants. Moreover, salivary flow rate was assessed as a potential, new stress marker. Contrary to the expectations, neuroticism did neither predict the subjective stress reaction positively, nor did it predict the salivary flow rate negatively after a social stress task (Trier Social Stress Test, TSST). Neuroticism, however, positively predicted threat appraisal and threat appraisal positively predicted subjective stress. These findings support the Transactional Model of Stress and Coping by showing a significant association for threat appraisal and the subjective stress reaction. Moreover, the results emphasize the importance of threat appraisal for individuals with high expressions of neuroticism. Lastly, this study did not find salivary flow rate to either significantly increase or decrease following the TSST. Further research with a larger sample and additional stress measures needs to be conducted to gain insight into the association between neuroticism and stress expression as well as the salivary flow rate in response to stress.

*Keywords*: Neuroticism, salivary flow rate, stress, threat appraisal, transactional model of stress and coping

**Zusammenfassung**

Neurotizismus und langanhaltende Stresserfahrungen sind allgemein bekannte Risikofaktoren für die Entwicklung psychischer Störungen. Zusätzlich ist bekannt, dass negative Reaktionen auf stressige Ereignisse mit einer höheren Ausprägung des Neurotizismus zunehmen. Daher ist es wichtig, die Mechanismen zu verstehen, die diese Anfälligkeit für Stress vermitteln. Darüber hinaus ist immer noch umstritten, ob Personen mit einer hohen Neurotizismus-Ausprägung tatsächlich eine verstärkte subjektive Stressreaktion zeigen. Deshalb untersucht diese Studie mit 42 weiblichen Teilnehmerinnen, inwiefern die Tendenz, eine Situation als bedrohlich zu bewerten in Verbindung zu Neurotizismus steht. Außerdem wurde die Speichelflussrate als potenzieller Stressmarker untersucht. Entgegen den Erwartungen sagte Neurotizismus weder die subjektive Stressreaktion positiv hervor, noch die Speichelflussrate nach einer sozialen Stressaufgabe (Trier Social Stress Test, TSST) negativ. Jedoch bestand ein positiver Zusammenhang zwischen Neurotizismus und der Tendenz, Situationen als bedrohlich zu bewerten, was wiederrum subjektives Stresserleben positiv vorhersagte. Diese Ergebnisse stützen das Transaktionsmodell von Stress und Bewältigung, da sie einen signifikanten Zusammenhang zwischen der Bedrohungseinschätzung und der subjektiven Stressreaktion verdeutlichen. Darüber hinaus unterstreichen die Ergebnisse die Bedeutung der Bewertungen einer Situation als bedrohlich für Personen mit hohem Neurotizismus. Schließlich wurde in dieser Studie keine signifikante Veränderung der Speichelflussrate nach dem TSST festgestellt. Weitere Untersuchungen mit einer größeren Stichprobe sollten durchgeführt werden, um Erkenntnisse über den Zusammenhang zwischen Neurotizismus und Stressausdruck sowie über die Speichelflussrate als Reaktion auf Stress zu gewinnen.

*Schlüsselwörter*: Bedrohlichkeits-Bewertung, Neurotizismus, Speichelflussrate, Transaktionales Stressmodell