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What came first? Exploring temporal precedence for daily perceived stress and quality of social interactions

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Abstract

Objective: Stress and social interactions are integral aspects of daily life that each exert a strong influence on mental and physical health. They are joined by a complex, and at times, obscure relationship, where one can influence the other, and vice versa, in both a beneficial and a detrimental way. This thesis examined the relationship between perceived stress and the quality of social interactions in daily life. Specifically, it explored whether stress predicts subsequent changes in the positivity and negativity of social interactions, or vice versa. *Method:* Using an ecological momentary assessment design, data were collected over 30 days for men, and over one menstrual cycle for women. Each evening, the 69 participants reported on their daily perceived stress and their daily number of positive and negative interactions, yielding 1,820 valid observations. Multilevel modeling was applied to analyze same-day and cross-day associations, while controlling for autocorrelation, gender, and long-term stress. *Results:* Higher daily stress was significantly associated with a lower same-day ratio of positive to negative social interactions. Cross-day analyses indicated no lagged effects. However, a non-significant trend suggested that higher stress might predict a lower ratio of positive to negative interactions the following day. This trend was not observed for the quality of social interactions predicting next-day stress. *Conclusion:* There was evidence for a same-day association between stress and the quality of interactions, but no temporal precedence across days. Subtle trends point toward potential delayed effects of stress on subsequent social interactions, warranting further investigation.

Keywords: perceived stress, positive social interactions, negative social interactions, ecological momentary assessment

Contents

Introduction

A well-known proverb states, “Shared joy is a double joy; shared sorrow is half sorrow” (Pei & Zaki, 2025, p. 124). There is substantial evidence that supports this statement, indicating that social connection is a powerful resource that can both increase happiness and buffer the effects of psychological strain. However, despite these generally beneficial effects, rates of social connection have been decreasing. Loneliness has emerged as a notable public health crisis, even during young adulthood, which has traditionally been considered a highly social phase of life (Pei & Zaki, 2025). This development can be attributed, at least in part, to broader social and economic trends such as globalization and educational emphasis on refining human capital, which may contribute to job insecurity and a reduced focus on socio-emotional skills essential for positive interpersonal interactions (Rojas et al., 2025).

Today’s demanding daily routines often cannot be sustained without continuous physical and psychological efforts (Mariotti, 2015). Stress-related costs to the healthcare system are estimated at several billion euros per year in European countries such as Germany, Switzerland, the United Kingdom, and France (European Agency for Safety and Health at Work., 2014). The ongoing trend toward decreases in social connection and increases in stress, despite efforts to mitigate both (Pei & Zaki, 2025; Piao et al., 2024; Taylor et al., 2023), emphasizes both the relevance of the problem and the difficulties in treating it. Yet, studies examining the two phenomena and how they relate to each other in daily life remain scarce.

This master’s thesis seeks to contribute to closing that gap. The thesis primarily aims to evaluate the relationship between stress and the quality of social interactions in daily life, paying particular attention to the underlying temporal dynamics of this association. It begins by outlining the theoretical foundations of stress and social interactions, both separately and in relation to one another. Then, it presents the methodology and results of the current investigation. Lastly, the findings are discussed in the context of existing literature.

Stress

A recently published longitudinal study comparing daily stress levels across more than 149 countries and almost 2.5 million people found that, between 2008 and 2020, emotional stress worsened in 85% of the assessed countries (Piao et al., 2024). This observation continues a trend already seen in the 1990s and 2010s in the United States and extends its

impact to a global level (Almeida et al., 2020). So, not only is stress already a pervasive phenomenon, but it is and has been increasing worldwide (Piao et al., 2024).

Why is that an issue? Stress is known to be an important factor in the onset, maintenance and exacerbation of a multitude of mental and physical health problems, e.g. cardiovascular diseases, Alzheimer's disease, cancer, depression and autoimmune diseases (Klein et al., 2016; Piao et al., 2024). It has also been linked to an increase in overall mortality and specific somatic health symptoms such as headache, back pain, and influenza, as well as decreases in life satisfaction (DeLongis et al., 1988; Klein et al., 2016). Consequently, increases in global stress are also likely to lead to increases in health problems, thereby increasing the public health burden (Piao et al., 2024).

While the negative impact of stress on health has been well documented in numerous studies, the definition and *conceptualization of stress* is less clear (Klein et al., 2016; Piao et al., 2024). Generally, stress is considered from three different perspectives: environmental, biological, and psychological (Klein et al., 2016). At the *environmental* level, it is important to note that not only major life events such as death or illness can be a stressor. Daily hassles such as workplace demands, car maintenance, and even recreational activities can be stressful (DeLongis et al., 1988; Nater et al., 2020).

On both a physiological and psychological level it is important to consider that stress, although it is often more so associated with its negative long-term consequences, is first and foremost an *adaptive reaction* to ensure survival in threatening situations. As such, being able to react to stressors with a physiological and psychological stress response is indispensable for our survival (Sandi & Haller, 2015).

Transactional Model of Stress and Coping

Thus, experiencing a stressful event or a series of such events does not necessarily have to be related to worse health outcomes. So, what determines the impact stress has? According to the *transactional stress model* by Lazarus and Folkman (1984), which primarily assesses the psychological component of stress, the impact of a stressor is largely based upon the appraisal of said stressor. More specifically, the model postulates that two different appraisal processes occur when encountering a stressor (Lazarus & Folkman, 1984).

During *primary appraisal,* a stressor is assessed as irrelevant, benign-positive or dangerous. Dangerous stressors have the potential to cause stress. They can either be

considered harm/loss, threat, or challenge. Harm and loss respectively mean that some form of damage has already occurred (e.g., losing a loved one). A threat is defined as anticipated harm or loss (e.g., finding out that a loved one is severely ill). Subsequently, threats are accompanied by negative emotions, such as fear and anger. Challenges are similar to threats in that something is anticipated. However, the key difference is that challenges result from stressors that are primarily considered for their potential benefits rather than their potential detriments (e.g., taking a university entrance exam for which one feels prepared). Accordingly, challenges are accompanied by positive emotions such as excitement and exhilaration (Lazarus & Folkman, 1984).

When examining the concepts of challenge and threat, one thing becomes clear: whether something is perceived as a threat or a challenge largely depends on one's resources. For instance, taking an important university entrance exam without studying is likely to evoke feelings of anxiety and self-doubt, resulting in a threat state rather than a challenge state. The transactional stress model acknowledges the importance of resources through the concept of *secondary appraisal*. During secondary appraisal, an individual evaluates their own coping abilities and the likelihood of applying them. If an individual interprets their own resources as insufficient, stress occurs (Lazarus & Folkman, 1984).

It is important to note that primary and secondary appraisal do not occur independently of each other. Rather, the assessment of the stressor (primary appraisal) and of one's resources (secondary appraisal) interact with each other and influence how much stress is experienced together. For example, ahead of a high-stakes university entrance exam, feelings of anxiety are likely to persist, even with ample preparation and social support. Thus, it is likely that the situation will result in a threat state. In contrast, if admission to the university is not as important to the student because they dislike the university's curriculum or already have a place in a different program, they will be able to apply their resources much more effectively. The exam will likely be seen as a challenge rather than a threat, resulting in a lower level of stress (Lazarus & Folkman, 1984).

Coping occurs after concluding both primary and secondary appraisal. According to Lazarus and Folkman (1984) there are two kinds of *coping* – emotion-focused, and problem-focused. Emotion-focused coping aims to alleviate the emotions associated with stress (e.g., watching a movie to distract oneself from the anxiety of exam preparation). In comparison, problem-focused coping attempts to change the situation itself (e.g., studying to be more

prepared). After coping, the stressor and one's own resources might be reappraised, which may result in changes to the level of stress experienced (Lazarus & Folkman, 1984).

Chronic Stress and Allostatic Load

So, when and how does stress become dangerous? Although stress is adaptive in the short-term, long-term stress can be disruptive. Persistent or very intense stressors become increasingly difficult for individuals to deal with, which starts to affect their coping abilities and efforts (Mariotti, 2015). This may result in *increased emotion-focused coping*, which in and of itself can be detrimental to one's health (e.g., by increasing alcohol consumption to cope with aversive affective states) and has been linked to lower levels of performance (Lazarus & Folkman, 1984). Moreover, prolonged stress can trigger *maladaptive physical reactions*. These reactions are important because they play a key role in explaining how stress can lead to negative consequences for physical and mental health (Nater et al., 2020).

But why is that? To understand, we must first have a look at what happens physiologically when we encounter a stressor. Our bodies are comprised of homeostatic and allostatic systems. While *homeostatic* systems, such as blood oxygen levels, must remain within a very narrow range, *allostatic* systems have much broader limits. Allostatic systems allow our bodies to adequately adapt to a wide variety of stressors, such as infections, encounters with wild animals, and public speaking tests. When we encounter a stressor, the hypothalamic-pituitary-adrenal (HPA) axis and the autonomic nervous system become more active. This leads to increased secretion of stress hormones such as adrenaline, noradrenaline and cortisol. Together, these hormones prepare the body for the necessary reactions to a threat. Once the threat has passed, the body returns to its original equilibrium, or homeostasis (McEwen, 1998; Nater et al., 2020). This process is called *allostasis*, fittingly defined as the "ability to achieve stability through change" (McEwen, 1998, p. 171).

But what happens when the body cannot return to its equilibrium because the threat never passes? According to McEwen (1998), persistent activation of allostatic systems can cause *allostatic load*. Allostatic load describes the attrition the body sustains due to overexposure to stress hormones (McEwen, 1998). For example, consider the hippocampus: During acute stress the release of catecholamines and glucocorticoids can amplify the creation of emotionally charged memories (McEwen, 2002). Nevertheless, glucocorticoids

and excitatory amino acid neurotransmitters released during and after stress have been observed to cause neural atrophy in the CA3 region of the hippocampus. This atrophy is reversible in cases where stress is short-lived. However, sustained stress can cause permanent morphological changes in the hippocampus (McEwen, 1998).

Similar detrimental effects of prolonged stress have been observed in other areas of the brain, including the prefrontal cortex, basal ganglia, and limbic system. Research suggests that the affective, behavioral, and cognitive changes associated with prolonged stress may result from these morphological adaptations (Mariotti, 2015). Additionally, they likely increase *vulnerability* to various mental health disorders (Lupien et al., 2018; Mariotti, 2015). In line with this observation, neuroimaging shows that the morphological changes associated with prolonged stress are similar to those associated with various stress-related illnesses (Mariotti, 2015). For example, atrophy of the hippocampus has been observed in stress-related illnesses, such as post-traumatic stress disorder and recurrent depressive disorder (McEwen, 1998).

Still, chronic stress affects more than just the brain. Other physiological systems affected by allostatic load include the *cardiovascular, metabolic, and immune systems*. Taking this into account helps explain the other detrimental health effects of stress. Stress wears down the cardiovascular system in a similar fashion to the brain, and it does so again for the metabolic and immune system. This is why incidences of coronary heart disease and diabetes, as well as the severity of the common cold, are increased by stress (McEwen, 1998).

Inter- and Intraindividual Differences in Stress Reactivity

Although these stress-induced physiological changes affect everyone, not everyone is equally vulnerable to them. But why is that? Current research supports the idea that individual stress reactivity is influenced by a wide variety of both *inter- and intraindividual factors* (Huang et al., 2013). Among these interindividual factors are a person's sex, age, overall health, cardiorespiratory fitness, level of obesity, and even genetics (Huang et al., 2013; Nater et al., 2020).

One aspect that is especially well documented is the influence of *childhood trauma* on physiological stress reactivity (Lupien et al., 2018; Nater et al., 2020). One study found that women who experienced physical or sexual abuse in childhood showed higher stress

reactivity of the HPA-axis and the autonomic nervous system than the control group. This hyperreactivity appears to be related to increased secretion of the corticotropin-releasing factor (CRF), which is found in the amygdala, hypothalamus, and neocortex and also seems to be closely related to the occurrence of anxiety and depressive disorders (Heim et al., 2000). Yet, the impact of other factors on stress reactivity is less clear. For instance, although men and women have been observed to differ in their physiological reactions to stress, recent findings suggest that some of these seemingly apparent *sex differences* might be more so related to *gender* expression and socialization rather than biological sex (Lupien et al., 2018).

In addition to these interindividual differences, stress reactivity was also observed to be dependent on *intra-individually varying factors* (Weber et al., 2022). For instance, *sleep deprivation* was found to be linked to alterations in cortisol stress reactivity. Sleep-deprived individuals showed higher baseline levels of cortisol and an attenuated cortisol response to a stressor (Vargas & Lopez-Duran, 2017). Furthermore, when comparing different types of *laboratory stressors*, psychosocial stressors were shown to induce the most severe stress reaction in the HPA-axis compared with physical stressors (Schwabe et al., 2008; Weber et al., 2022). An especially prominent factor affecting stress reactivity appears to be *perceived control over the situation*. Specifically, an increase in control over a situation has been observed to be related to a lowered heart rate, blood pressure, and catecholamine secretion. Consistent with this finding, it was proposed that psychological appraisals can influence and predict physiological reactions (Huang et al., 2013).

Considering the type of stressor and its psychological appraisal have both been observed to impact physiological stress reactivity, it is reasonable to perceive a parallel with the transactional stress model. As a reminder, Lazarus and Folkman (1984) proposed that the manifestation of *psychological stress* depends on the appraisal of the stressor itself and of one's personal coping abilities (Lazarus & Folkman, 1984). From a *physiological perspective*, this association appears to be similar, with both the stressor itself and its psychological appraisal impacting physiological stress reactivity (Huang et al., 2013; Schwabe et al., 2008; Weber et al., 2022).

Social Interactions

Like stress, another important factor influencing well-being and health is social connection. A substantial amount of scientific evidence suggests that being socially

connected and having satisfying relationships has the potential to decrease mortality and disease burden (Holt-Lunstad et al., 2017). On the other hand, social isolation and loneliness have consistently been linked to worse health outcomes, with a mortality risk similar to obesity and cigarette smoking (Taylor et al., 2023). In addition to the clear individual cost of these health issues, there are broader economic consequences. Specifically, health issues that are attributable to a lack of social connection are associated with increased use of social and healthcare services, as well as decreased productivity, both paid and unpaid (Mihalopoulos et al., 2020).

These findings are already concerning, but it is perhaps most notable that they are far from isolated. As of 2021, ten meta-analyses and at least 276 independent studies had evidenced the connection between *social connection and health*, with data collected across various settings, populations, methods, and operationalizations. While one must be exceptionally careful when attributing causality to any scientific finding, the extensive evidence has led authors like Holt-Lunstad (2022) to consider the probability of a causal link between social connection and health (Holt-Lunstad, 2022). Drawing upon the often cited Bradford Hill guidelines in epidemiology and a data integration framework from various scientific disciplines she concludes, “[The] cumulative evidence supports the likelihood of a causal link between strong social connections and both better health and longer life” (Holt-Lunstad, 2022, p. 201).

This robust body of evidence contrasts sharply with *current societal rates of social connection*. Although loneliness is often considered a problem primarily affecting older adults, research offers a more nuanced picture. In fact, most studies indicate that loneliness levels among older adults tend to remain relatively stable over time (Buecker et al., 2021). By comparison, young adults were traditionally considered to be more socially connected (Pei & Zaki, 2025). However, a recent large-scale meta-analysis concluded that emerging adults have experienced a steady increase in loneliness over the past four decades (Buecker et al., 2021). Thus, the generational gap in loneliness appears to be narrowing, largely due to a decline in social connection among young adults (Pei & Zaki, 2025).

The wealth of evidence demonstrating the impact of social connection on health has recently inspired various countries and organizations worldwide to recognize loneliness and social isolation as growing public health issues (Holt-Lunstad et al., 2017). As a result, campaigns such as “Ending Loneliness Together” in Australia and the “Campaign to End

Loneliness" in the United Kingdom were created (Taylor et al., 2023). One especially noteworthy development is the World Health Organization's acknowledgment of social support networks as one of the key determinants of health, as it highlights the global importance of social connection (Holt-Lunstad et al., 2017; Taylor et al., 2023; World Health Organization, n.d.).

Conceptualizing Social Connection

While this recognition is laudable, it is likely that it could have occurred sooner. One barrier to research on social connection appears to be the fact that it can be *defined and measured in various ways*. Some terms used in scientific literature include social isolation, loneliness, social support, social conflict, positive, and negative social interactions, among numerous others (Holt-Lunstad, 2022; Taylor et al., 2023). To amend this issue and provide structure, the term *social connection* has recently been proposed as an umbrella term for all social factors impacting health (Holt-Lunstad, 2022).

Nevertheless, just like individual relationships, social connection remains a complex, nuanced and multifaceted research topic. For analytical purposes, it is often separated into three components: relationship structure, function, and quality. *Relationship structure* refers to observable aspects of social ties, such as marital status, the size of one's social network, the regularity of social interactions, and living arrangements (e.g., living alone or with others). *Function* pertains to the extent to which these connections meet various needs, such as providing emotional or tangible support. The functional component is often evaluated through measures of actual or perceived social support or, conversely, through indicators of loneliness. While functional measures may overlap with quality, the *quality* component captures distinct emotional dimensions of social ties. These include both positive and negative aspects, such as relationship satisfaction, intimacy, feelings of inclusion or exclusion, and social conflict. Unlike functional aspects, these qualities are not defined by the support they offer, but rather by the emotional experience they create. However, they may still play a role in fulfilling important psychological needs. For example, intimacy can fulfill attachment needs (Holt-Lunstad, 2022). Despite this overlap, correlations between the three components appear to be modest, supporting the idea of them being distinct types of social connection (S. Cohen et al., 2000; Holt-Lunstad, 2022).

The Role of the Quantity and Quality of Social Interactions

Although the terms *social isolation* and *loneliness* are often used together to signify a lack of social connection, the distinctions introduced in the previous paragraph highlight the fact that they are not interchangeable. Specifically, indicators of social isolation are part of the *relationship structure* dimension and as such, can often be assessed quantitatively (e.g., by frequency of social interactions or number of relationships). In contrast, indicators of loneliness relate to the *functional component* of social connection and are therefore largely subjective (Holt-Lunstad, 2022).

This distinction is well-established, as scholars have long emphasized the difference between social isolation and loneliness (Silva et al., 2023). The *cognitive discrepancy model* further supports this distinction by defining loneliness as the discrepancy between an individual's actual and desired level of social connection. Importantly, this discrepancy can occur both qualitatively and quantitatively. For instance, someone with a large social network may still feel lonely if they lack a close confidant, reflecting a deficit in the quality of their social connections. Conversely, another individual might experience loneliness because their social network is too small to meet their desired level of social interaction, indicating a quantitative shortfall. Meanwhile, a third person with the same size or quality of social network may not feel lonely at all if their desire for social connection is already met. Thus, loneliness is shaped not only by the objective size and structure of one's network, but also by individual preferences and perceptions (Peplau & Perlman, 1982).

Drawing from existing research, the difference between the first two hypothetical individuals experiencing loneliness may, statistically, be a difference in age. This is because the quantity of social interactions tends to be more indicative of well-being in younger adults, whereas the quality of social interactions plays a more influential role in the well-being of older adults. This *age-related difference* is thought to stem from shifting developmental goals. In early adulthood, central goals include expanding one's social network and acquiring new knowledge. These goals are often pursued through broad and frequent social interactions. In contrast, emotional closeness becomes increasingly important with age, making intimate, high-quality interactions more meaningful for older adults (Zhaoyang et al., 2019). Consequently, younger individuals are more protected against loneliness by the quantity of social interactions, while those in mid- and later life are more protected by the quality of social interactions (Victor & Yang, 2012).

The Quality of Social Interactions

However, this does not mean that the quality of social interactions is unimportant for young adults. In fact, the *quality of social interactions* matters across all age groups. For example, Silva et al. (2023) conducted a study with participants ranging in age from 18 to 73, with a relatively low mean age of 33.1 (*SD* = 14.6). The study examined which types of social interactions were most effective in alleviating loneliness and resulted in the realization that simply engaging in more social interactions was not sufficient. Instead, interactions characterized by positive qualities, such as enjoyment, meaningfulness, authenticity, connection, and safety were associated with lower same-day loneliness. In contrast, interactions lacking these positive qualities, or involving negative qualities such as threat or rejection, were linked to greater same-day loneliness. While the study did not focus on age differences specifically, the wide age range of the participants suggests that the findings may be relevant across age groups. Additionally, the younger skew of the sample provides particular support for the relevance of these effects among younger and middle-aged individuals (Silva et al., 2023).

Conceptualizing Positive and Negative Social Interactions

Silva et al.'s (2023) findings underscore the importance of positive and negative interaction qualities in influencing daily experiences of loneliness. Furthermore, their work offers a helpful reference point for defining these interaction types. Nevertheless, as previous studies have varied considerably in their *conceptualization of positive and negative interactions*, it is essential to further clarify these definitions (Lincoln, 2000; Silva et al., 2023).

Negative interactions are often broadly defined and can encompass a wide range of behaviors that elicit psychological distress (e.g., feelings of sadness, anger, or shame). Examples include making critical, threatening, or dismissive remarks, discouraging the expression of emotions, violating personal boundaries, and failing to follow through on promises (Lincoln, 2000; Silva et al., 2023).

Although *positive interactions* can also be described in terms of their experiential qualities (e.g., enjoyment and safety (Silva et al., 2023)), they are commonly operationalized as a core component of *social support* (Woodward et al., 2018). Sometimes, positive

interactions are even used interchangeably with social support (Lincoln, 2000). Social support is often divided into four components: affectionate support (e.g., feeling loved), tangible support (e.g., help with chores), emotional/informational support (e.g., advice), and positive social interactions (e.g., an uplifting encounter) (Sherbourne & Stewart, 1991; Woodward et al., 2018). While only one component is termed "positive social interactions", the others also involve forms of supportive, affirming engagement that can be experienced as positive interactions more broadly. For instance, helping with daily chores fulfills functional needs and can enhance relationship quality and emotional closeness. This is why positive social interactions and social support are sometimes used interchangeably (Lincoln, 2000; Woodward et al., 2018).

The Relationship Between Positive and Negative Social Interactions

In their investigation of the impact of social interactions on loneliness, Silva et al. (2023) also investigated whether the effects carried over to the following day. They found that negative, but not positive, social interactions predicted next-day loneliness. This suggests that *negative interactions* have a *more enduring* impact than *positive interactions*. Therefore, reducing negative social interactions may be a more effective way to promote social connection than increasing positive interactions (Silva et al., 2023).

This observation raises an important question: Should social interactions be viewed as existing on a single continuum ranging from negative to positive? Or are negative and positive interactions distinct constructs that should be studied separately? Prior research suggests that the latter is more accurate. Positive and negative interactions appear to be *two independent constructs* that require separate study (Lincoln, 2000; Zhaoyang et al., 2019). Despite this distinction, research over the past few decades has disproportionately focused on the positive aspects of social ties, while the negative aspects have received considerably less empirical attention (Laurence, 2019; Lincoln, 2000). This *imbalance* is especially notable given the growing academic consensus that the detrimental impact of negative social interactions may be even greater than the beneficial impact of positive social interactions (Harada et al., 2018; Lincoln, 2000; Silva et al., 2023). However, existing research shows that it would be far too simple to assume that positive social interactions are, without exception, preferable to negative ones. For instance, in the context of relationship satisfaction, Bartle-Haring et al. (2024) discovered that positive characteristics

only predicted greater happiness when accompanied by some negative characteristics (Bartle-Haring et al., 2024). Thus, positive and negative social interactions should be investigated together, as distinct (Lincoln, 2000) but complimentary (Bartle-Haring et al., 2024) concepts.

It is especially uncommon for research to explore the impact of both positive and negative social interactions simultaneously. Nevertheless, several *theoretical models* addressing the relationship between positive and negative social interactions have emerged. Although these models lack sufficient empirical support to confirm their applicability, they do help organize previous scientific findings. Two of the most prominent models addressing the effects of social interactions on well-being are the *additive effects model* and the *buffering effects model* (Harada et al., 2018; Lincoln, 2000).

As the name implies, the *additive effects model* posits that positive and negative interactions contribute independently to well-being, with positive interactions having beneficial and negative interactions having detrimental effects. Studies employing this model generally find that, although positive interactions are more common, they tend to have weaker effects on well-being than negative interactions. However, empirical findings are not always consistent. Some studies report equivalent effects for both interaction types. Additionally, there are isolated findings that suggest positive interactions can be more impactful. One potential explanation for these discrepancies is the use of *different methodologies*, particularly different questionnaires. For example, some studies used standardized instruments, while others did not. Standardized assessments of negative interactions were particularly uncommon. Furthermore, the content and length of the questionnaires varied, which could have influenced the observed effects. To address this issue and improve the interpretability and comparability of the findings, Lincoln (2000) recommends that future investigations should employ parallel measures of positive and negative social interactions (Lincoln, 2000).

Unlike the additive effects model, which posits that the impact of social interactions on well-being is cumulative, the *buffering effects model* hypothesizes that positive social interactions can mitigate the detrimental effects of negative ones (Harada et al., 2018). Assuming negative social interactions are conceptualized as stressors, this concept aligns closely with other theoretical frameworks. For example, Cohen and Wills's (1985) stress-buffering model of social support postulates that social support can buffer the harmful

effects of stress on well-being. However, unlike the model by Cohen and Wills (1985), empirical findings on the buffering effects model have been inconsistent (S. Cohen & Wills, 1985; Harada et al., 2018). One likely explanation for these inconsistent findings is the failure to consistently account for the source of the interaction. It makes a difference whether the person offering social support is also the person who initiated the conflict earlier, or whether the person is someone who had nothing to do with the original negative encounter. Therefore, this distinction between *same-source buffering* and *cross-source buffering* is crucial. When it is taken into account, empirical evidence for both types of buffering can be found (Harada et al., 2018; Lincoln, 2000).

The Relationship between Stress and Social Interactions

One can see that the area of social interactions is a broad phenomenon with numerous facets to consider and examine. But how do stress and social interactions relate to each other? When looking at how the two phenomena interact with each other, it appears that the relationship between them is *bidirectional*. This is evidenced on the one hand by stress that can lead to social withdrawal and a worsening in the quality of social interactions (Dissing et al., 2019; Sandi & Haller, 2015), or conversely, increased social support seeking (Juster et al., 2016). On the other hand, both social isolation and interpersonal conflicts can themselves result in an increased experience of stress (daSilva et al., 2021; Girardi et al., 2015), whereas social support can reduce stress (Holt-Lunstad, 2022; Woodward et al., 2018).

To better understand the mechanisms underlying this bidirectional and multi-layered relationship, it is helpful to examine how social interactions are integrated into established models of stress. Two particularly relevant frameworks are the *transactional model of stress and coping* (Lazarus & Folkman, 1984) and the concept of *allostatic load* (McEwen, 1998), both of which were explored in detail in the first section of this master's thesis.

Social Interactions and the Transactional Model of Stress and Coping

To recap: The transactional model emphasizes the roles of *cognitive appraisal* and *coping* in response to stressors (Lazarus & Folkman, 1984). More specifically, the model postulates that to be experienced as stressful, a situation must first be perceived as threatening and, secondly, as exceeding personal coping abilities (Schäfer et al., 2023). Only then will an

individual experience stress and start to cope with the stressor, either by employing emotion-focused or problem-focused coping strategies (Lazarus & Folkman, 1984). Social interactions, particularly *social support*, can be integrated into this model as key factors influencing the entire process (DeLongis et al., 1988; Lazarus & Folkman, 1984).

First, during primary and secondary appraisal, the perceived availability of social support can reduce the likelihood that a situation will be appraised as threatening or overwhelming to one's personal resources. For instance, ahead of a high-stakes exam, knowing that your loved ones will continue to support you regardless of the outcome can make the situation feel more manageable. Second, during the coping phase, emotional, tangible, or other social support from your network can be a valuable resource in dealing with the stressor. For example, your loved ones might validate your anxiety, distract you by spending time with you, or help you study. Thus, social support can help you employ both emotion-focused and problem-focused coping strategies (DeLongis et al., 1988; Lazarus & Folkman, 1984).

Although Lazarus and Folkman (1984) emphasize the beneficial effects of social support on stress in their model, it is reasonable to consider how negative social interactions and social conflict could also be incorporated into the model. For instance, researchers studying both positive and negative social interactions have sometimes defined negative interactions as a type of stressor (Lepore, 1992). Alternatively, negative interactions may be viewed as having the opposite effect of social support: Current research suggests that negative social interactions have the potential to exacerbate the effects of stress on well-being (Lincoln, 2000). Based on this observation, one could hypothesize that negative interactions can increase the likelihood that a stressor will be appraised as threatening or overwhelming to one's personal resources, as well as hinder coping efforts. For example, telling someone that failure is shameful and a sign of low intelligence before a high-stakes exam would likely make the situation feel more threatening and reduce the number of people one feels comfortable going to for support, thereby undermining coping efforts.

Social Interactions and Allostatic Load

While the transactional model highlights the importance of cognitive appraisal and coping for stress, the concept of allostatic load refers to the *cumulative physiological attrition* sustained through chronic stress (Lazarus & Folkman, 1984; McEwen, 1998). Seeman et al. (2002) explored how *social connection influences allostatic load* across two

age groups: a younger cohort (aged 58 – 59) and an older cohort (aged 70 – 79). Allostatic load was measured using a comprehensive multi-system index, reflecting cumulative biological risk, rather than isolated system-specific indicators. The measures included systolic and diastolic blood pressure, waist-to-hip ratio, total cholesterol, and serum dehydroepiandrosterone sulfate (DHEA-s), a functional HPA axis antagonist, among others (Seeman et al., 2002).

Measures of *social integration* varied across cohorts. For the younger group, assessments included both early-life parental care and later-life experiences with significant others (e.g., spouses). For the older cohort, only current social interactions were assessed, using two dimensions: relationship structure (i.e., total number of social ties) and relationship function/quality. The latter was evaluated using items developed by the authors to assess positive interactions, such as tangible and emotional support, as well as negative interactions, such as interpersonal conflict and excessive demands (Seeman et al., 2002).

Overall, the results indicated that *positive social relational experiences* were associated with *lower mean allostatic load* in both cohorts, with the association being especially pronounced in the younger cohort. In the older cohort, the structural measure of social integration (i.e., number of social ties) and the functional measure of positive interactions (i.e., tangible and emotional support) were both negatively correlated with allostatic load. Although no significant gender differences were observed, these associations only reached statistical significance for men. Additionally, there was some evidence that *negative interactions*, particularly with spouses and children, were linked to *elevated allostatic load* for both men and women in the older group (Seeman et al., 2002).

Stress and the Quantity of Social Interactions

The findings by Seeman et al. (2002) offer initial evidence that a greater number of social ties is associated with lower allostatic load (Seeman et al., 2002). But what else can be said about the bidirectional relationship between stress and the *quantity* of social interactions?

Research on *rodents* has consistently linked experiencing a stressor to a reduction in the number of social interactions, regardless of whether the stressor was social or non-social in origin (daSilva et al., 2021). For instance, Haller and Bakos (2002) found that rodents exposed to a stressor engaged in significantly less social interactions and exploration behavior the following day (Haller & Bakos, 2002). However, support for a similar association

in *humans* is less distinct (daSilva et al., 2021). On the one hand, stress is associated with a reduction in social contact and an increase in avoidant behavior and emotionality during social interaction (e.g. less smiling, less eye-contact, fewer displays of affection) (Repetti & Wood, 1997). On the other hand, humans tend to cope with stress using social support (daSilva et al., 2021).

To better understand the temporal dynamics between stress and social interactions, studies using an *ecological momentary assessment* (EMA) design are particularly valuable, as they are both longitudinal in nature and capture the association between phenomena in a naturalistic setting. One EMA study found that, like rodents, higher levels of perceived stress predicted a decrease in social interactions the following day, whereas a reverse pattern of social interactions predicting perceived stress could not be detected. These findings support a *unidirectional* link, at least in the short term, from *stress* to *reduced social engagement* (daSilva et al., 2021).

Considering the importance of social support seeking, this observation might seem counterintuitive. However, research shows that people typically only seek a moderate amount of social support from a few people closest to them (Armstrong III & Kammrath, 2015). As such, when confronted with a stressor, they likely do not increase their social interactions (daSilva et al., 2021). Instead, they change their way of communicating with the people closest to them to elicit support.

Although the previous findings by daSilva et al. (2021) support a unidirectional link from stress to reduced social engagement, the question remains: Can the quantity of social interactions also influence stress? To investigate this, Forbes et al. (2022) conducted an EMA study with five measurement points per day, examining the impact of social interactions on momentary stress. They found that having experienced *at least one social interaction* of at least two minutes duration since the last measurement point was associated with *lower momentary stress*. Interestingly, having more than one interaction during the same time frame did not yield additional benefits. Based on these findings, one could hypothesize a *threshold effect*, whereby the presence of some social contact reduces stress, but increased quantity beyond this threshold does not further enhance the outcome. Still, the effect was only observed in one of the two assessed cohorts. Specifically, the smaller cohort showed no effect of social interaction quantity on momentary stress (Forbes et al., 2022). Thus, further research is needed to ascertain the reliability of these findings, particularly since they

contrast somewhat with those of daSilva et al. (2021). It is important to note, however, that daSilva et al. (2021) examined the effect of social interactions on stress the following day, whereas Forbes et al. (2022) measured stress and social interactions multiple times per day (daSilva et al., 2021; Forbes et al., 2022). Based on this difference in timing, the potential stress-buffering effects of social interactions may be relatively short-lived.

Stress and the Quality of Social Interactions

Consequently, stress appears to negatively affect the *quantity* of social contact sought out by an individual, while evidence for a reverse pattern association remains limited. But what about the *quality* of social interactions? How is stress related to the quality of social interactions, and vice versa?

As previously mentioned, existing research emphasizes the fact that social support, especially in the form of positive social interactions, plays an important role in alleviating stress (Woodward et al., 2018). However, chronic stress may gradually erode the very social support it depends on (Lepore et al., 1991). Additionally, stress has been linked to the maintenance of fewer social relationships (Dissing et al., 2019). Yet, *stress* not only has the potential to *diminish social support*, but it can also *increase relational conflict*. For example, epidemiological studies suggest that various stress-inducing factors, such as economic crises, are correlated with higher rates of crime and violence. Furthermore, childhood maltreatment has been linked to antisocial behavior later in life, often described as part of a "cycle of violence". Yet, experiencing adversity does not inevitably result in harming others. The concept of "altruism born of suffering" exemplifies this idea, proposing that stress can have prosocial effects. After all, former victims are often motivated to prevent others from experiencing similar adversity or to support those who do (Sandi & Haller, 2015). Despite this, the overall impact of stress on the quality of social interactions appears to be more harmful than beneficial. Though the precise mechanisms through which stress undermines social functioning remain insufficiently understood.

One *plausible pathway* through which stress affects the quality of social interactions involves increased avoidant behavior and decreased emotionality, as noted in the previous section. For example, stress may lead to a reduction in eye-contact and displays of affection (Repetti & Wood, 1997). Additionally, chronic and high stress can lead to a series of related symptoms such as fatigue, anxiety, and depressive symptoms, which themselves may impair

social functioning (Dissing et al., 2019). For instance, depressive symptoms have been linked to poorer emotion regulation, increased self-focus, and less smiling (Kupferberg et al., 2016). Meanwhile, increased anxiety has been shown to predict fewer friendships and less perceived social support (daSilva et al., 2021). In the context of early-life adversity and subsequent violent or prosocial behavior, genetic predispositions may influence the outcome (Sandi & Haller, 2015).

Unlike the relationship between stress and the *quantity* of social interactions, the literature search yielded no EMA studies that investigate the impact of stress on the *quality* of social interactions. Consequently, the temporal and situational dynamics underlying this association in daily life remain largely unexplored.

However, there is some evidence addressing the *reverse pattern*: the impact of the quality of social interactions on stress. As previously discussed, social interactions, particularly social support, can be incorporated into both the transactional model of stress and coping and the concept of allostatic load. In addition to these theoretical frameworks, a few isolated EMA studies have examined how these two phenomena interact in daily life. For instance, Forbes et al. (2022) investigated the relationship between the pleasantness of interactions and momentary stress. To do so, they administered a visual analogue scale five times daily for one week. Their findings indicated that higher pleasantness of social interactions predicted lower stress levels at the next measurement point (Forbes et al., 2022). Bernstein et al. (2018) reported similar results, though their EMA study was shorter, spanning three days with six daily measurements. In addition, it did not include a lagged association between variables, but assessed stress and the pleasantness of social interactions simultaneously (Bernstein et al., 2018).

Research Gap

In summary, stress and social connection are two intricately intertwined constructs. Although each greatly impacts physical and mental health (Holt-Lunstad et al., 2017; Klein et al., 2016), chronic stress and deficits in social connection remain widespread, unresolved individual and public health issues (Buecker et al., 2021; Piao et al., 2024). Thus, furthering the scientific understanding of these phenomena and their association is a highly relevant task.

While the detrimental effects of stress are well-documented (Klein et al., 2016), research on social connection has often concentrated on either the frequency of interactions (daSilva et al., 2021; Elmer et al., 2025) or on positive aspects such as social support (Laurence, 2019; Lincoln, 2000). However, a more comprehensive approach that not only considers the quantity but the full spectrum of interaction quality, including negative aspects is needed (Elmer et al., 2025; Silva et al., 2023; Zhaoyang et al., 2019). This is emphasized by a growing academic consensus that the harmful effects of negative social interactions may outweigh the benefits of positive ones (Harada et al., 2018; Lincoln, 2000; Shin & Park, 2023; Silva et al., 2023). A further challenge in this area of research is the inconsistency in how positive and negative interactions are assessed, which impairs direct comparison and interpretation of findings. To address this, scholars recommend the use of equivalent measurement approaches for both constructs (Lincoln, 2000).

One particularly valuable approach to studying the association between stress and social interactions is offered using *EMA studies*. EMA studies usually take place over several days or weeks in participants' natural environment. Due to their design, they provide near real-time measurements, which avoids recall biases and long intervals between experiences and their scientific recording (Smyth et al., 2017; Zhaoyang et al., 2019). Although there is more extensive evidence for the relationship between stress and the quantity of social interactions (daSilva et al., 2021; Forbes et al., 2022), only two studies that examine the relationship between stress and the quality of social interactions using ecologically valid measurements were found throughout the literature search. Both studies were limited to short time frames of three and seven days, respectively, and only one investigated the directionality of findings (Bernstein et al., 2018; Forbes et al., 2022). To better capture fluctuations and long-term patterns, longer EMA studies are needed. Considering the complex relationship between stress and the quality social interactions and their considerable effect on well-being, examining the temporal relationship between these two variables in a naturalistic setting could help clarify their association.

Research Questions and Hypotheses

Thus, based on this theoretical and empirical background the aim of this thesis is to assess the relationship between daily stress and quality of social interactions. In accordance with the transactional model of stress and coping, stress will be measured as *perceived*

stress rather than the stressful events themselves (Lazarus & Folkman, 1984). Furthermore, in this thesis, the umbrella term *quality* of social interactions specifically refers to how positive or negative an interaction was perceived to be.

To fulfill the aim for this thesis, *three research questions* that each comprise *one hypothesis* will be used. Although positive and negative social interactions represent distinct components of social connection (Lincoln, 2000; Zhaoyang et al., 2019), it is important to understand how these distinct components relate to each other (Bartle-Haring et al., 2024; Lincoln, 2000). That is why the three hypotheses will investigate the ratio of daily positive to negative interactions and its relationship with daily perceived stress.

Looking at the three research questions individually, the first research question (RQ1) evaluates to what degree perceived stress and the number of positive and negative interactions reported on the *same day* (day t) are related (main effect). Then, the second research question (RQ2) assesses the influence perceived stress on one day (day t) may have on the number of positive and negative social interactions reported the *following day* (day t+1), examining a potential carry-over effect. Lastly, the third research question (RQ3) focuses on a possible vulnerability or stress-buffering effect, examining whether the number of positive and negative social interactions reported on one day (day t) can predict perceived stress levels the *following day* (day t+1). All hypotheses are directional because of the empirical findings presented earlier. In addition to the hypotheses, supplementary expectations of results are stated for further clarification.

Research Question 1: How is daily perceived stress associated with the number of positive and negative social interactions reported the same day? (main effect)

H1: There is a negative relationship between perceived stress and the ratio of positive to negative interactions reported the same day.

Expectation of results: Higher perceived stress on day t is associated with a lower ratio of positive relative to negative social interactions on day t. Lower perceived stress on day t is associated with a higher ratio of positive relative to negative social interactions on day t.

Research Question 2: Can daily perceived stress predict the number of positive and negative social interactions the following day? (carry-over effect)

H2: There is a negative relationship between perceived stress on one day and the ratio of positive to negative interactions reported the following day.
Expectation of results: Higher perceived stress on day t predicts a lower overall quality of social interactions on day t+1, reflected by a decrease in the numerical value of the ratio of positive to negative social interactions. Lower perceived stress on day t predicts a higher overall quality of social interactions on day t+1, reflected by an increase in the numerical value of the ratio of positive to negative social interactions.

Research Question 3: Can the number of positive and negative social interactions predict perceived stress the following day? (vulnerability/stress-buffering effect)

H3: There is a negative relationship between the reported ratio of positive to negative social interactions on one day and perceived stress the following day.
Expectation of results: A higher overall quality of social interactions on day t, reflected by a higher numerical value of the ratio of positive to negative social interactions on day t, predicts a decrease in perceived stress on day t+1 (stress-buffering effect). Conversely, a lower overall quality of social interactions on day t, reflected by a lower numerical value of the ratio of positive to negative social interactions on day t, predicts an increase in perceived stress on day t+1 (vulnerability effect).

Method

This investigation is part of a study that is currently being conducted at the Institute for Clinical and Health Psychology at the University of Vienna examining the alpha-amylase awakening response (AAR) and its relationship with stress. As such, answering the research questions presented in this thesis is not the primary aim of the study. The fact that the study, known internally as the AAR study, was not originally designed to address the research questions of this master's thesis places some limitations on the research. For example, it means that the measures used were not specifically selected to fit the research questions presented in this thesis. In addition, this thesis is not the only one that has used the AAR study as a framework. Other students who are or have been involved in the study include Anne Baumgartner, Anton von Hinüber, Leonie Hofinger, Ivana Joketovic, Sara Milos, Marie Charlotte Preußer, Rebekka Sattelberger, Clara Charlotte Vornholt and Alexander Lifu Winkler (listed alphabetically).

The AAR study uses an EMA design and utilizes both psychological self-reports and biological data collected from saliva samples. While some psychological variables, such as long-term stress, are assessed only once, others, such as perceived stress and the number of positive and negative social interactions experienced during the day, are assessed daily. The biological data, which was collected as part of the larger study, had not been analyzed at the time of writing this thesis and was therefore not used in this investigation.

Procedure

Participants were recruited by posting flyers (see Appendix 1) throughout the city of Vienna in grocery stores, fitness centers, on the campuses of various universities, as well as through the "Studo" app, which has a location-based feature and is primarily used by students. Another platform used for recruitment was the Study Participant Platform (SPP) of the Vienna Cognitive Science Hub. Its mission is to connect a diverse group of students interested in participating in research with researchers conducting studies in cognitive science. For this purpose, it uses the hroot software (Bock et al., 2014).

Once a participant was recruited, the AAR study staff used a standardized telephone call lasting approximately 15 minutes to assess whether the participant met all inclusion criteria and was therefore eligible to participate. Eligible candidates were then invited to the Faculty of Psychology to provide informed consent and to collect the materials required for participation (i.e., supplies for the collection of saliva samples and study phones). In addition, participants were asked to fill out questionnaires that assess various trait measures using the Unipark computer software (Tivian XI GmbH, Cologne, Germany).

While men were free to begin their participation in the study on a date of their choosing, shortly after their first appointment, women were required to begin their participation on the second day of their menstrual cycle, which was timed to also take place shortly after their first appointment. For the duration of 30 days for men and one menstrual cycle for women, participants were then asked to provide three daily saliva samples in the first 30 minutes of the day. They also completed short (3-5 minute) questionnaires each morning and evening at a time of their choosing using the smartphone app movisensXS, Version 1.5.23 (movisens GmbH, Karlsruhe, Germany). Both perceived stress and the number of positive and negative social interactions experienced during the day were assessed in the evening questionnaires.

At the end of their participation, the men and women were invited back to the Faculty of Psychology to complete further questionnaires (e.g., the PSS-10) and to return the study materials, i.e. the saliva samples and study phones. All participants were compensated with 100€ for their contribution.

Sample

The AAR study plans to recruit 45 men and 45 women. There are several criteria that participants must fulfill to be a part of the study. For example, they should be between the ages of 18 and 35, be both mentally and physically healthy and have a normal BMI, ranging between 18 and 25. Additionally, women must have a regular menstrual cycle and not be using hormonal contraception, be pregnant or breastfeeding. Similarly, participants should not use illicit drugs or any medication that affects the HPA axis. Both nicotine and alcohol consumption should be limited. As the study is being conducted in German, participants must be fluent in German.

At the time of data analysis for this master's thesis, 72 individuals had completed their participation in the AAR study. Three participants had to be excluded from the final data analysis due to poor data quality. Consequently, this thesis uses a dataset of 69 participants who participated in the study between November 2022 and March 2025. The remaining sample consisted of 40 females (58%) and 29 males (42%) with an average age of 23.83 (*SD* = 3.79; Min = 19, Max = 43). The oldest participant was a man, who was included in the study despite being 43 years old, due to human error. However, he remains part of this sample, as being younger than 35 is not a requirement for this investigation. Educational attainment and current employment status were not recorded. However, as recruitment was mainly targeted at university students, it is likely that a significant majority of participants were university students.

Operationalization

While the AAR study includes a variety of measures, this thesis primarily uses two daily measures and one one-time measure. The daily measures include the four-item version (PSS-4) of the Perceived Stress Scale (S. Cohen et al., 1983), and the number of positive and negative social interactions experienced during the day. The measure that was assessed only once was the ten-item version (PSS-10) of the Perceived Stress Scale (S. Cohen et al., 1983).

While the daily measures were the main variables used in this thesis, the PSS-10 was used alongside gender (0 = male, 1 = female) as a covariate. In the following section, each variable is described regarding its origin, as well as its suitability and psychometric properties, in cases where the necessary information was available.

Social Interactions

To evaluate the positivity and negativity of social interactions experienced throughout the day, two self-designed questions were used ("How many positive social interactions did you have today?" and "How many negative social interactions did you have today?"). Social contacts and their positivity and negativity were thereby defined as follows: "All contacts (with family, friends, colleagues, etc.) that last longer than 5 minutes are considered social contact. All contacts after which you felt better than before are considered positive. All contacts after which you felt worse than before are considered negative."

Perceived Stress Scale

The Perceived Stress Scale (PSS) is a widely used self-report measure focusing on the psychological component of stress. More specifically it assesses how life has been experienced as being unpredictable, uncontrollable and overloaded, usually in the past month (Klein et al., 2016). It was originally developed by Cohen et al. (1983) with the intention of creating a psychometrically valid questionnaire that assesses perceived stress in accordance with the transactional stress model (S. Cohen et al., 1983; Lazarus & Folkman, 1984). While its original version included 14 items, two shortened versions, using ten and four items respectively, have since been developed (S. Cohen et al., 1983; Ribeiro Santiago et al., 2020).

PSS-4. For the everyday assessment of perceived stress, a German four-item version of the PSS (PSS-4) was used. While the two longer versions of the PSS are generally understood to measure two factors, the PSS-4 is usually considered to contain only one factor. Although there have sometimes been doubts about the factorial structure of this version (Schäfer et al., 2023).

Furthermore, the PSS-4 has sometimes been criticized for having only marginally acceptable reliability. Specifically, in approximately half of all studies examining its psychometric properties, Cronbach's alpha fails to meet the generally accepted threshold of

> .70, which would indicate adequate internal consistency (Lee, 2012). Individual values for Cronbach's alpha range between .60 and .82 (Demkowicz et al., 2020; Lee, 2012).

The PSS-4 has been shown to have good convergent validity with mental health variables such as anxiety and depression (Sanabria-Mazo et al., 2023; Vallejo et al., 2018) as well as good discriminant validity with measures of posttraumatic growth and resilience (Sanabria-Mazo et al., 2023). In addition, it can distinguish between groups with different demographic characteristics, i.e. gender, age, employment status, income, nationality, education, marital status, and parental status (Sanabria-Mazo et al., 2023; Vallejo et al., 2018).

Despite the criticisms of the PSS-4's psychometric quality, it is still widely used in research, especially in studies with a longitudinal design (e.g., EMA studies). This is because longitudinal studies are time-consuming for participants, which can lead to compliance issues and high dropout rates. Therefore, the PSS-4 is the most appropriate daily measure to assess perceived stress in this investigation (Schäfer et al., 2023).

Participants in the AAR study are instructed to complete the German PSS-4 each evening. The items thereby refer to the experience of stress throughout the past day, which is a departure from the original design of the questionnaire, which refers to the previous month. For example, the fourth item of the questionnaire asks, “How often *today* have you felt difficulties were piling up so high that you could not overcome them?” (S. Cohen et al., 1983). Answers can be given on a 5-point scale ranging from 0 (= "never") to 4 (= "very often"). To interpret the results, the scores for items two and three must first be reversed. The sum of all four items is then interpreted, with higher scores indicating greater levels of perceived stress (S. Cohen et al., 1983; Schäfer et al., 2023).

PSS-10. The most widely used version of the PSS is the ten-item version (PSS-10), which is owed in large to the fact that it has the best psychometric quality of all three variations (Lee, 2012). In contrast to the PSS-4, there is little doubt that it measures two factors, perceived helplessness and perceived self-efficacy. Although some isolated studies could not confirm the two-factorial structure (Lee, 2012; Schäfer et al., 2023).

In a review of 12 studies assessing the psychometric quality of the PSS-10, all of them described Cronbach's alpha values of > .70, indicating satisfactory internal consistency. In addition, four studies reported on the test-retest reliability of the PSS-10. Again, the desired value of > .70 was met each time (Lee, 2012).

Like the PSS-4, the PSS-10 has been shown to correlate positively with validated measures of depression and anxiety (Lee, 2012; Reis et al., 2019; Xiao et al., 2023). Additionally, the concurrent validity of the PSS-10 has been assessed through positive correlations with constructs such as stigma, symptom severity, and insomnia severity (Reis et al., 2019; Schneider et al., 2020; Xiao et al., 2023). In contrast, physical health, mental health, and well-being, as well as social support, family functioning, and positive caregiving experiences, have been shown to be negatively correlated with the PSS-10 (Schneider et al., 2020; Xiao et al., 2023).

As part of a series of questionnaires, participants in the AAR study fill out the German version of the PSS-10 at their last in-person appointment at the Faculty of Psychology. In accordance with the original version of the questionnaire, the items refer to the experience of stress during the previous month. For example, the fourth item of the questionnaire asks, “In the last month, how often have you felt confident about your ability to handle your personal problems?” (S. Cohen et al., 1983; Schneider et al., 2020). Responses can be given on a 5-point scale ranging from 0 (= "never") to 4 (= "very often") (S. Cohen et al., 1983). To interpret the results, the scores for items four, five, seven and eight, which constitute the self-efficacy scale, must be reversed. The sum of all ten items is then interpreted, with higher scores indicating greater levels of perceived stress (Schneider et al., 2020).

Analytic Strategy

The statistical analyses for this thesis were conducted using IBM SPSS Statistics Version 29.01.0 (171) and JASP Version 0.95.1. While SPSS was primarily utilized for preliminary analyses and assumption checks, JASP was used to conduct the main analyses and to create the figures.

In consideration of the hierarchical data structure, in which daily measurements (Level 1) were nested within participants (Level 2), multilevel models (MLM) were fitted. This approach allows the baseline and the relationship between multiple variables to vary both between-persons and within-persons. To estimate the MLMs, maximum likelihood estimation was employed, which enabled direct comparisons between models. The models were created stepwise, gradually making them more complex. Model comparisons were conducted using chi-square likelihood ratio tests, as well as the goodness-of-fit indices,

Akaike Information Criterion (AIC), and the more conservative Bayesian Information Criterion (BIC) (Field, 2017).

However, to gain an initial understanding of the data and confirm that the hierarchical structure of the data has a substantial influence upon the results, the analysis began with calculating the intraclass correlation coefficients (ICC) for daily perceived stress, positive interactions, negative interactions, and the adjusted ratio of positive to negative social interactions. The adjusted ratio was necessary because a standard ratio cannot be computed when the denominator equals 0. Thus, the adjusted ratio was created by adding a constant (k = 0.5) to both positive and negative interaction counts. In addition, a natural logarithm transformation was applied to the new fraction, as it makes the ratio more resistant to bias and improves stability, especially in cases where the data includes a lot of zero values. The final formula for the adjusted ratio of positive to negative social interactions was as follows:

$$\text{adjusted interaction ratio} = ln\left(\frac{positive\ interactions + k}{negative\ interactions + k}\right)$$

While this adjusted ratio is much more resistant to zero values, it is important to note that the log transformation changes its interpretation. An adjusted ratio of zero ($ln = 0$), now represents equal amounts of positive and negative interactions. An adjusted ratio greater than zero ($ln > 0$) represents more positive than negative interactions, and an adjusted ratio less than zero ($ln < 0$) denotes more negative than positive interactions.

Statistical Model

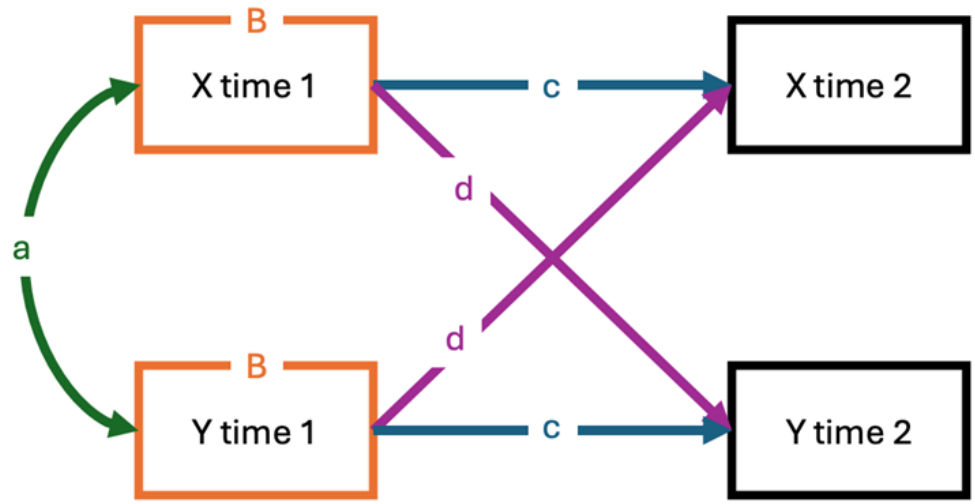
Looking at the research questions and hypotheses for this thesis, one of the main interest points is assessing the directionality of the association between perceived stress and social interactions. But how is that possible, given that the study does not have an experimental design?

Even though causality can only be derived from experiments, the design of an EMA study still offers potentially causal pathways by way of studying temporal precedence (Hamaker et al., 2015). The corresponding statistical phenomenon, known as Granger causality, describes the observation that previous values of a variable X can sometimes predict values of a variable Y better than simply previous values of Y. Thus, the concept describes the idea that some repeatedly assessed variables can improve the prediction of other repeatedly assessed

variables (Granger, 1969). The only question is: Which variable can best predict another variable? Although the possibilities for an answer to this question appear to be endless, one way to attempt an answer is through the use of repeated measurements and the construction of a corresponding cross-lagged panel model (Hamaker et al., 2015). An illustration of the cross-lagged panel model can be seen in Figure 1 (Morneau-Vaillancourt, 2023).

Figure 1

Illustration of the cross-lagged panel model



Note. Path *a* (green) represents the baseline association between two variables X and Y, path *c* (blue) represents stability or autocorrelation of a single variable over time, path *d* (purple) represents the cross-lagged association between X and Y over time. From *X for Cross Lag,* by G. Morneau-Vaillancourt, December 1, 2023, The EDIT Blog. https://blogs.kcl.ac.uk/editlab/2023/12/01/x-for-cross-lag/. Copyright 2025 by The EDIT Blog.

In relation to the research questions in this thesis, RQ1 examines path *a*, assessing whether there is a same-day association between perceived stress (Variable X) and the adjusted ratio of social interactions (Variable Y). This serves as the foundation for

subsequent analyses. RQ2 and RQ3 then investigate paths *d*, determining whether there is directionality to this association. Specifically, they address the question: Does perceived stress predict changes in the quality of social interactions (RQ2), or is the reverse true (RQ3)? When investigating directionality, it is important to statistically account for path *c*, the stability of the predictor over time. Therefore, model estimation for RQ2 and RQ3 starts by incorporating the previous day's outcome values as opposed to the previous day's predictor values, ensuring proper control for temporal stability.

Results

A total of 69 participants provided 1,820 valid daily assessments, along with 328 missing values. Participants on average completed the study after 30.4 days (*SD* = 2.5, Min = 23, Max = 39). The sample comprised 40 females (58%) and 29 males (42%), with a mean age of 23.83 years (*SD* = 3.79, Min = 19, Max = 43). Table 1 presents descriptive statistics for the main variables used in this analysis, including the mean, standard deviation, range, and ICC.

Table 1

Descriptive Statistics

Variable	*M*	*SD*	Min	Max	ICC
Level 1					
PSS-4	4.8	3.0	0	15	.49
Positive Interactions	4.0	3.5	0	30	.35
Negative Interactions	0.4	0.8	0	10	.25
Interaction Ratio (adj.)	1.6	0.9	-1.9	4.1	.29
Level 2					
PSS-10	20.9	3.0	15	30	

Note. ICC = Intraclass Correlation Coefficient; PSS = Perceived Stress Scale; adj. = adjusted

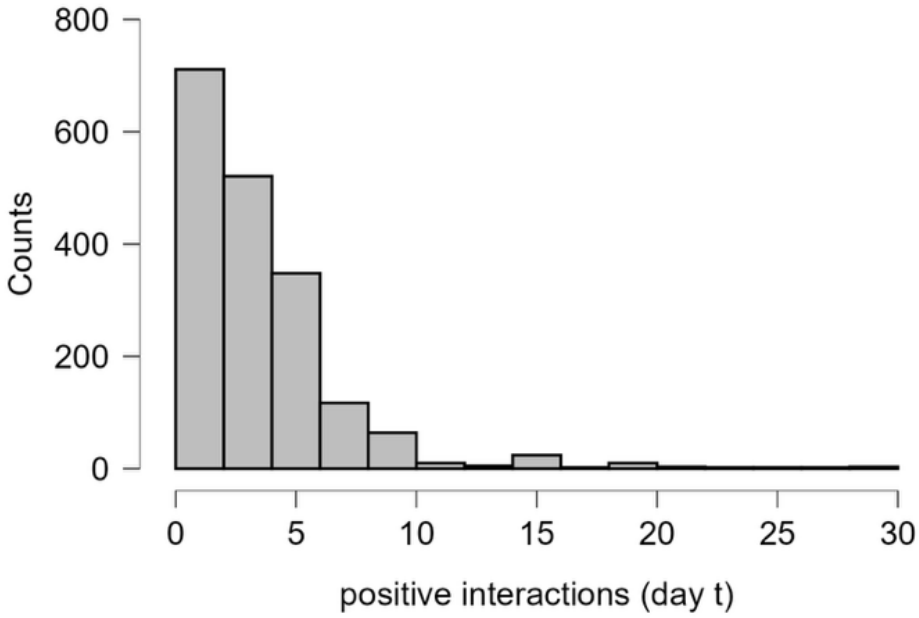
Overall, PSS-4 scores in this sample were similar to normative values reported for the general population (Warttig et al., 2013). However, long-term stress, as measured by the PSS-10, was notably elevated. Compared to a general population sample of adults aged 20 – 39 years (*M* = 12.74, *SD* = 6.67), the mean PSS-10 score in this study exceeded the population mean by more than one standard deviation. This indicates that participants experienced comparatively high stress throughout their time of participation (Klein et al., 2016).

Preliminary Analyses

The ICC calculations confirmed that the hierarchical structure of the data substantially influences the results, underscoring the need for using multilevel modeling. ICC values indicate the proportion of variance within a variable that is attributable to between-person differences. As shown in Table 1, daily perceived stress demonstrated the highest between-person variance compared to other variables. Among the different types of social interactions, positive interactions varied more between individuals than negative interactions, suggesting greater individual differences in positive interactions. Moreover, positive interactions occurred more frequently than negative interactions, which were less common and often valued at zero. Figures 2 and 3 depict the detailed distributions of positive and negative interactions, respectively.

Figure 2

Distribution of positive social interactions reported per day

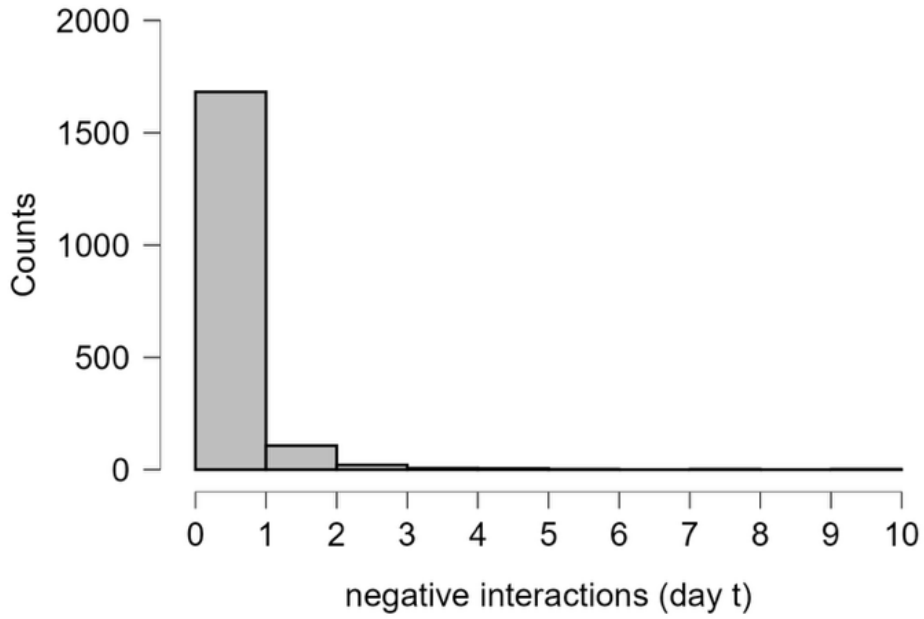


Note. The x-axis indicates the maximum number of positive interactions reported per day.

From JASP Team (2025). JASP (Version 0.95.1) [Computer software].

Figure 3

Distribution of negative social interactions reported per day



Note. The x-axis indicates the maximum number of negative interactions reported per day.

From JASP Team (2025). JASP (Version 0.95.1) [Computer software].

Employing benchmarks established by J. Cohen (1988), current day perceived stress was strongly positively correlated with perceived stress the following day (r = .62, p < .001). Negative social interactions exhibited a small positive correlation with same-day perceived stress (r = .16, p < .001) and a smaller positive correlation with perceived stress the next day (r = .10, p < .001). On the contrary, positive social interactions exhibited a small negative correlation with same-day perceived stress (r = -.18, p < .001) and a smaller negative correlation with subsequent-day perceived stress (r = -.12, p < .001). The adjusted ratio of positive to negative interactions was also negatively correlated with perceived stress, indicating that stress may be associated with fewer positive interactions and more negative ones. Specifically, the ratio displayed a small-to-moderate negative correlation with same-day perceived stress (r = -.26, p < .001) and a small negative correlation with perceived stress measured the next day (r = -.16, p < .001). Positive and negative interactions shared a small positive correlation (r = .09, p < .001) (J. Cohen, 1988).

After completing these preliminary analyses, the necessary assumption checks for the use of a multilevel model were conducted. The assumptions of linearity and

homoscedasticity were confirmed to be fulfilled via the use of partial and residual plots. A histogram and a P-P Plot revealed the data to be approximately normally distributed, with some skew to the left for the first and second hypothesis, and some skew to the right for the third hypothesis. Although standardized residuals indicated the presence of some outliers, all Cook's distances were below the commonly used threshold of 1. Therefore, exclusion of these cases was not warranted. Collinearity diagnostics using tolerance and variance inflation factors (VIF) revealed no problematic multicollinearity.

Main Analyses

The results of the assumption checks allowed the use of multilevel modeling to investigate all three research questions. For RQ1, the investigation began directly with the analysis of interest, with a model that included the primary predictor and random intercepts. The inclusion of random intercepts allows the baseline of the outcome variable to vary between individuals. The second model then added random slopes, permitting the relationship between the predictor and outcome to vary between individuals. As previously discussed, model estimation for RQ2 and RQ3 began by incorporating the previous day's outcome values, also starting with a model that only included random intercepts and then progressing to a model of random intercepts and slopes. Then, the main analysis was conducted similarly to that for RQ1. After the model with the best model fit was found, subsequent analyses examined whether the inclusion of the covariates long-term stress and/or gender further improved model fit for each research question. To determine each covariate's distinct explanatory value, and to mitigate potential suppression effects, the covariates were entered both individually and simultaneously in separate models. As the estimation of correlated random intercepts and slopes consistently led to numerical problems with the maximum-likelihood estimate (e.g., gradients too large), all models were fitted with the somewhat unrealistic assumption of uncorrelated random effects.

Research Question 1

The first research question examined the *same-day relationship* between daily perceived stress and the ratio of positive to negative interactions. It was hypothesized that higher levels of daily stress would be associated with a lower adjusted ratio of positive to negative social interactions, and vice versa. The models calculated for RQ1 are summarized in Table 2.

Model 1 included only the primary predictor daily perceived stress, with random intercepts. Model 2 extended this by adding random slopes. Daily stress emerged as a highly significant negative predictor (b = -0.07, p < .001) in both models. A likelihood ratio test comparing the two models indicated a highly significant improvement in model fit when random slopes were included (p < .001). This finding was further supported by reductions in both AIC and BIC values. Consequently, Model 2 was retained as the better-fitting model.

In Model 3, long-term stress was added as a covariate. Compared to Model 2, this addition significantly improved model fit, as evidenced by a significant likelihood ratio test (p < .05) and a decrease in AIC values, although BIC values did not decrease. Furthermore, daily stress remained a highly significant predictor (p < .001) and long-term stress emerged as an additional significant predictor (p = .012). Notably, daily stress continued to be negatively associated with the adjusted interaction ratio (b = -0.07), whereas long-term stress was positively associated with the variable (b = 0.05).

For Model 4, long-term stress was replaced with the covariate gender. Gender was not a significant predictor (p = .067) and did not improve overall model fit compared to Model 2. While the AIC was slightly lower than in Model 2, the BIC remained higher, and the likelihood ratio test was not significant (p > .05).

Finally, Model 5 integrated all three predictors: daily stress, long-term stress, and gender. It was compared to the insofar best model, Model 3. The addition of gender did not improve model fit, as reflected by a non-significant likelihood ratio test (p > .05) and equal or higher AIC and BIC values. Consistent with earlier results, long-term stress remained significant (p = .026), whereas gender did not (p = .162). Subsequently, Model 3 was accepted as the final model, as it was the model with the overall best model fit.

In sum, the final model indicates that participants reported *fewer* positive interactions relative to negative ones on days when they experienced higher levels of daily stress. The opposite was true for long-term stress; higher levels were associated with *more* positive than negative daily interactions. Since gender did not improve model fit or demonstrate a significant relationship with the interaction ratio, it was not included in the final model. Overall, the accepted model for the first research question illustrates that both same-day stress and long-term stress are meaningfully related to one's positive and negative interactions on a given day, whereas a person's gender does not meaningfully impact their daily social interactions.

Table 2

Model summary for hypothesis 1, predicting the adjusted interaction ratio (t)

	Model 1	Model 2	Model 3	Model 4	Model 5
Fixed effects					
Intercept	1.98***	1.97***	0.94*	1.96***	1.05*
Daily Stress (t)	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***
Long-Term Stress			0.05*		0.04*
Gender				-0.11	-0.08
Fit indices					
Deviance	4,145	4,130	4,124	4,127	4,122
df	4	5	6	6	7
AIC	4,153	4,140	4,136	4,139	4,136
BIC	4,175	4,168	4,169	4,172	4,175

Note. df = degrees of freedom; AIC = Aikake information criterion; BIC = Schwarz's Bayesian information criterion

* $p \leq .05$ ** $p = .001$ *** $p < .001$

Research Question 2

The second research question investigated whether daily perceived stress on one day (day t) could predict positive and negative interactions the following day (day t+1). It was hypothesized that higher stress on one day would be associated with a decrease in the adjusted ratio of positive to negative social interactions the next day. Conversely, lower stress one day was hypothesized to be associated with an increase in next day's adjusted ratio of positive to negative social interactions. Table 3 summarizes the models tested for RQ2.

Model estimation began with an initial model (Model 1) that included only the outcome variable, the interaction ratio on day t+1, and its previous day's value, the interaction ratio on day t, with random intercepts. Model 2 included the same variables but additionally allowed for random slopes. These first two models were designed to evaluate the degree of *autocorrelation* before introducing the main predictor. In both models, the previous day's interaction ratio was a highly significant predictor ($b = 0.15$, $p < .001$), indicating substantial autocorrelation in the outcome. When comparing the two models, a likelihood ratio test was not significant ($p > .05$), and both AIC and BIC values increased, signaling no improvement in

model fit with random slopes. As a result, Model 1 was accepted as the better-fitting baseline model.

The *main analysis* started with Model 3. Model 3 added daily stress (day t) as the primary predictor and included random intercepts. Although daily stress was not statistically significant (b = -0.01, p = .110), model fit improved relative to Model 1, as indicated by a significant likelihood ratio test (p < .001), and lower AIC and BIC values. Given this improvement and the theoretical importance of daily stress, Model 3 was retained. Model 4 introduced random slopes for daily stress. Like in the previous model, daily stress remained non-significant (p = .114). Additionally, model fit worsened, as was confirmed by a non-significant likelihood ratio test (p > .05) and increases in both AIC and BIC values. Thus, random slopes were not included in future analyses and Model 3 remained the preferred model.

After concluding the main analysis, Models 5 through 7 examined the potential impact of *covariates*. Model 5 assessed long-term stress, Model 6 assessed gender, and Model 7 incorporated both covariates simultaneously. In all three models, none of the predictors reached statistical significance. Specifically, in Model 5, daily stress (p = .090) and long-term stress (p = .160) were both not significant. In Model 6, daily stress (p = .089) and gender (p = .300) were not significant. Similarly, in Model 7, daily stress (p = .078), long-term stress (p = .221), and gender (p = .441) did not achieve significance. Furthermore, none of these models demonstrated improved model fit over Model 3, as evidenced by all likelihood ratio tests failing to reach statistical significance (p > .05) and all AIC and BIC values being equal to or greater than those for Model 3.

Based on these results, Model 3 was accepted as the final model for RQ2. However, it should be noted that the only significant predictor (p < .001) across all seven models was the previous day's adjusted interaction ratio. Model 3, the chosen model, also incorporated the non-significant predictor, daily stress (p > .05). Nevertheless, Model 3 was chosen as the final model due to its superior model fit. None of the covariates tested in later models improved the model fit or reached statistical significance. Consequently, in this sample, the previous day's interaction ratio was the only variable that significantly predicted the ratio of positive to negative social interactions on a given day.

Table 3

Model summary for hypothesis 2, predicting the adjusted interaction ratio (t+1)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Fixed Effects							
Intercept	1.39***	1.39***	1.50***	1.50***	0.94*	1.46***	1.00*
Adj. Interaction Ratio (t)	0.15***	0.15***	0.15***	0.15***	0.15***	0.15***	0.15***
Daily Stress			-0.01	-0.01	-0.01	-0.01	-0.02
Long-Term Stress					0.03		0.02
Gender						-0.06	-0.04
Fit Indices							
Deviance	3,651	3,651	3,632	3,632	3,630	3,631	3,630
df	4	5	5	6	6	6	7
AIC	3,659	3,661	3,642	3,644	3,642	3,643	3,644
BIC	3,681	3,688	3,669	3,677	3,675	3,675	3,681

Note. df = degrees of freedom; AIC = Aikake Information Criterion; BIC = Schwarz's Bayesian Information Criterion;

Adj. = Adjusted

* $p \leq .05$ ** $p = .001$ *** $p < .001$

Research Question 3

The third research question examined whether positive and negative interactions on one day (day t) could predict daily perceived stress the following day (day t+1), thus testing the reverse association of RQ2, i.e. a potential stress-buffering/vulnerability effect of social interaction quality. It was hypothesized that a higher ratio of positive to negative social interactions would be associated with a decrease in stress the following day (stress-buffering effect). On the contrary, a lower ratio of positive to negative social interactions was hypothesized to be related to an increase in stress the following day (vulnerability effect). A summary of the examined models for RQ3 is depicted in Table 4.

Model estimation for RQ3 followed the same approach as that for RQ2. The analysis began with a baseline model (Model 1) that included only the outcome variable, stress on day t+1, and its previous day's value, stress on day t, with random intercepts. Model 2 extended this by allowing random slopes. These first two models were designed to evaluate the degree of *autocorrelation* before introducing the main predictor. In both models, stress from the previous day was a highly significant predictor ($b = 0.29$, $p < .001$), indicating substantial autocorrelation in the outcome. The likelihood ratio test comparing the two models was not significant ($p > .05$). While the AIC was slightly lower for Model 2, the BIC increased. Because only one of the three model comparison indices suggested a minor improvement, the simpler Model 1 was accepted as the baseline model.

The *main analysis* started with Model 3. Model 3 added the adjusted interaction ratio (day t) as the primary predictor and included random intercepts. The interaction ratio was not statistically significant ($b = -0.01$, $p = .926$), and model fit worsened relative to Model 1, as evidenced by a non-significant likelihood ratio test ($p > .05$), and higher AIC and BIC values. As a result, Model 1 was retained. Given the clear non-significance of the predictor and the poorer model fit, Model 4, which would have introduced random slopes for the interaction ratio, was omitted. To maintain consistent numbering and comparability with RQ2, the subsequent model was labeled Model 5.

Models 5 through 7 examined whether *covariates* improved model fit or predicted next-day stress. Model 5 assessed long-term stress, Model 6 assessed gender, and Model 7 incorporated both covariates simultaneously. The adjusted interaction ratio was retained in these models, despite being non-significant in earlier models to ensure comparability and to determine whether the covariates could explain additional variance beyond daily social

interactions. In all three models, none of the predictors reached statistical significance. Specifically, in Model 5, the interaction ratio (p = .887) and long-term stress (p = .230) were both not significant. In Model 6, the interaction ratio (p = .867) and gender (p = .061) were not significant. Similarly, in Model 7, the interaction ratio (p = .843), long-term stress (p = .398), and gender (p = .096) did not reach significance. Furthermore, none of these models demonstrated improved model fit over Model 1, as shown by all likelihood ratio tests being non-significant (p > .05) and all AIC and BIC values being equal to or greater than those for Model 1.

In conclusion, stress from the previous day was the only predictor that significantly and consistently predicted the following day's stress (p < .001). The adjusted interaction ratio and the covariates did not significantly predict next-day stress, and none of the more complex models showed an improved model fit. Therefore, Model 1 was accepted as the final model for RQ3. Overall, this final model indicates that stress from the previous day is the only predictor of stress on a given day. In contrast, the previous day's social interactions, long-term stress, and gender do not predict stress on a given day.

Table 4

Model summary for hypothesis 3, predicting daily stress (t+1)

	Model 1	Model 2	Model 3	Model 5	Model 6	Model 7
Fixed Effects						
Intercept	3.42***	3.41***	3.43***	1.85	3.38***	2.28
Daily Stress (t)	0.29***	0.29***	0.29***	0.29***	0.29***	0.29***
Adj. Interaction Ratio			-0.01	-0.01	-0.01	-0.01
Long-Term Stress				0.08		0.05
Gender					-0.35	-0.32
Fit Indices						
Deviance	6,980	6,977	6,980	6,978	6,976	6,975
df	4	5	5	6	6	7
AIC	6,988	6,987	6,990	6,990	6,988	6,989
BIC	7,009	7,014	7,016	7,022	7,020	7,027

Note. df = degrees of freedom; AIC = Aikake Information Criterion; BIC = Schwarz's Bayesian Information Criterion;

Adj. = Adjusted

* $p \leq .05$ ** $p = .001$ *** $p < .001$

Discussion

Stress and social interactions share a complex, multi-layered, and, most importantly, *bidirectional relationship*. While stress can impair the quality of social interactions and prompt social withdrawal and social conflict (Dissing et al., 2019; Sandi & Haller, 2015), social conflict and isolation themselves can result in heightened stress (daSilva et al., 2021; Girardi et al., 2015). Conversely, social support can reduce stress (Holt-Lunstad, 2022; Woodward et al., 2018), yet chronic stress may gradually erode that same support (Lepore et al., 1991). Taken together, these dynamics can resemble a vicious cycle without a clear beginning or end. This master's thesis sought to bring some clarity to this cyclic relationship. In doing so, it specifically focused on the *temporal dynamics* underlying this association, exploring the question: Can daily stress temporally predict positive and negative interactions, or can interactions predict stress?

The findings provided only *partial support* for the proposed relationship. The first hypothesis, anticipating a same-day negative association between stress and the ratio of positive to negative interactions was supported. However, the second hypothesis (stress predicting next day's interaction ratio) and third hypothesis (interaction ratio predicting next day's stress) were both rejected. Consequently, there was evidence for a same-day association between stress and the quality of interactions, but the temporal relationship between the two variables remained inconclusive.

The following section discusses the findings for all *three research questions* in greater detail. As noted earlier, the *first research question* examined the relationship between stress and the ratio of positive to negative interactions reported on the *same day*, serving as the main effect and baseline for all subsequent analyses. It was hypothesized that daily stress would be negatively associated with the interaction ratio. The results supported this expectation: Daily stress was significantly and negatively related to the ratio of positive to negative interactions (b = -0.07, p < .001), highlighting its role in explaining same-day fluctuations in the quality of social interactions and leading to the *acceptance* of the first hypothesis. Additionally, long-term stress was significantly but positively related to the interaction ratio (b = 0.05, p < .05). At first glance, this pattern appears counterintuitive: Why would daily stress be associated with fewer positive compared to negative interactions, while long-term stress is related to more positive compared to negative interactions?

According to a study performed by Repetti and Wood (1997), *short-term stress* often elicits withdrawn interaction patterns, such as reduced affection and diminished eye-contact (Repetti & Wood, 1997). Additionally, short-term stress can result in high-arousal negative affect, which may be expressed through misplaced anger and aggression (Klumb et al., 2017). Short-term stress can also reduce social engagement overall (daSilva et al., 2021). Given that positive interactions were more common than negative ones in this study, a reduction in the total number of interactions would naturally lower the ratio of positive to negative interactions. Taken together, the negative association between daily stress and interaction quality aligns well with existing literature and expectations for the results.

The positive association between long-term stress and the interaction ratio, however, requires further consideration. One way in which *long-term stress* affects social functioning is through exacerbating related symptoms, such as fatigue, anxiety, and depressive symptoms (Dissing et al., 2019). However, participants in this study were required to be both mentally and physically healthy. Stress may intensify existing symptoms, but it may not directly cause these symptoms in otherwise healthy individuals. As a result, the exclusion criteria may have limited the expression of stress-related symptoms, thereby reduced the overall detrimental impact of long-term stress, and isolated its more direct effects. Another plausible explanation is that prolonged stress elicits compensatory behaviors, such as seeking social support or strengthening social ties, as coping mechanisms. During acute stress, individuals may temporarily withdraw and rely on a few close confidants (daSilva et al., 2021), but over time, this strategy becomes unsustainable. Consequently, long-term stress might encourage a reintegration of social interactions as a protective resource. Furthermore, although this finding may seem inconsistent with the findings of Lepore et al. (1991), who reported that a chronic environmental stressor can erode social support, the two results are not contradictory. In their study, a decline in social support emerged after eight months of continuous stress exposure, whereas participants initially reported heightened support after two months. The present study's measure of long-term stress corresponded more closely with the early phase of heightened social support described by Lepore et al. (1991), as it reflected a period of one month.

While the first research question examined the relationship between same-day stress and social interactions, the *second research question* focused on whether stress experienced on one day could predict the quality of social interactions reported the *following day.* In

other words, the second research question investigated a potential carry-over effect from one day to the next. It was hypothesized that daily stress would show a negative association with next day's ratio of positive to negative interactions. Although the results indicated the expected negative direction, the effect was not significant (b = -0.01, p = .110). Thus, contrary to the first hypothesis, the findings *did not support* the second hypothesis.

Nevertheless, the model which included *daily stress* as a predictor showed improved model fit compared to a model that only accounted for the temporal stability of the outcome, suggesting that daily stress might have captured some variance in next-day interaction quality beyond what was explained by the autoregressive effect alone. Subsequent models investigated the potential influence of gender and long-term stress as covariates. Neither variable reached statistical significance. However, it is noteworthy that their inclusion slightly reduced the p-value for daily stress, which *approached significance* in the last tested model (p = .078). This reduction in p-value after controlling for gender and long-term stress could be an additional indicator that daily stress has an independent effect upon the interaction ratio. If such an *effect* does exist, it is likely to be *small*. Preliminary correlational analyses revealed a small-to-moderate negative correlation between stress and the same day's interaction ratio (r = -.26, p < .001), but only a small negative correlation between stress and next day's interaction ratio (r = -.17, p < .001). Because these correlations do not account for the hierarchical data structure or the autocorrelation in the interaction ratio, the true within-person effect is likely even smaller. The stronger same-day correlation may explain why the first hypothesis yielded a significant result, whereas the carry-over effect was too weak to reach significance. The non-significant results, despite improved model fit, could also reflect limitations in *sample size*. Although the sample of 69 participants was not particularly small, it may not have been sufficiently large to detect subtle within-person effects. This is also evidenced by studies with similar designs and objectives using larger sample sizes (daSilva et al., 2021; Forbes et al., 2022). Another possible explanation concerns the temporal spacing of the measurements. The *measurement intervals* of 24 hours may have been too long for stress-related effects on social interactions to persist. It is possible that the influence of daily stress on social behavior dissipates within a shorter time frame. Future studies could therefore benefit from more frequent assessments, such as measurements every few hours.

The *third research question* examined a possible vulnerability or stress-buffering effect of social interactions on stress. Specifically, it investigated whether the ratio of positive to negative social interactions on one day could predict stress levels the *following day.* It was hypothesized that a larger interaction ratio would be associated with lower stress the next day (stress-buffering effect), whereas a smaller interaction ratio would be associated with higher stress the next day (vulnerability effect). However, the results of the analyses led to the *rejection* of the hypothesis. The previous day's interaction ratio did not significantly predict daily stress (b = -0.01, p = .926) or improve model fit. Moreover, the p-value remained large across all models and therefore provided no evidence of even a marginal effect. The only variable that approached significance, apart from the autoregressive term, was the covariate *gender* (Model 6: b = -0.35, p = .061; Model 7: b = -0.32, p = .096). These results suggest that men tended to report slightly higher daily stress levels than woman. This trend is noteworthy because normative data from the PSS-4 has typically shown the opposite pattern, with women reporting higher stress levels (Warttig et al., 2013). Nonetheless, the effect did not reach significance, and including gender did not improve the overall model fit.

The clearly non-significant findings for the third hypothesis *contrast* with findings of Forbes et al. (2022), who investigated the relationship between pleasantness of previous interactions and current stress levels. Since interaction pleasantness and the ratio of positive to negative interactions are similar indicators of social interaction quality, their effects on stress should be similar as well. Still, Forbes et al. (2022) discovered that higher interaction pleasantness was associated with lower stress levels at the subsequent measurement point, whereas, in the present study, the interaction ratio did not predict stress. However, upon closer comparison of the two studies, several methodological differences emerge that may explain the diverging results. For example, Forbes et al. (2022) assessed interaction pleasantness using a visual analogue scale rather than a ratio of positive to negative interactions. They also measured both variables five times per day, as opposed to the single daily assessment used in the present study. Most critically, however, Forbes et al. (2022) measured stress and the pleasantness of previously experienced interactions simultaneously, whereas in this investigation, stress and social interactions were assessed approximately 24 hours apart. Taken together, the shorter intervals between measurement points and the concurrent assessment of both variables, though interactions were assessed

retrospectively and stress was not, likely contributed to the stronger associations between variables.

Nonetheless, these closer assessments also make the *directionality* of effects in Forbes et al.'s (2022) study more difficult to interpret since both variables were measured simultaneously. In contrast, the one-day lag in the present study, though potentially too long to detect short-lived effects, permitted clearer temporal separation of the predictor and outcome variables. The non-significant findings for the second and third hypotheses suggest that neither stress nor the interaction ratio temporally predict the other variable from one day to the next. Yet, comparing the two directions still provides an important insight: The association from stress to next-day interaction quality appeared somewhat stronger than the reverse pattern.

This is notable because prior research has often focused on how social interactions influence stress rather than the other way around. Since stress and social connection are both crucial to physical and mental health, yet remain widespread issues (Buecker et al., 2021; Holt-Lunstad et al., 2017; Klein et al., 2016; Piao et al., 2024), understanding their bidirectional dynamics is important. The current results can be cautiously interpreted to suggest that reducing stress may be a more effective pathway toward more positive and less negative social interactions than promoting the quality of social interactions is a way to reduce stress levels.

Strengths and Limitations

The last section described how the clear temporal separation of variables is one of this thesis's most prominent *strengths*. This strength is mainly attributable to the EMA design of the study, which enabled near real-time data collection and minimized recall bias. The design also permitted interactions between stress and social interactions to be recorded in participants' daily lives, resulting in data with high ecological validity. Moreover, the study was relatively long, with data collection lasting 30 days for men and one menstrual cycle for women. This further supports the generalizability of the results to real-world situations because it provided a substantial data set and made the results less susceptible to momentary changes. Another strength of the study was its use of multilevel modeling. This reduced the impact of missing data and allowed for the separation of between- and within-person effects, thereby improving the informative value of the results. Although the

measures for positive and negative interactions consisted of only one brief, self-designed item each, their structural comparability represents an additional methodological strength.

However, this specific strength in operationalization cannot compensate for the fact that the operationalization of social interactions is also a prominent *limitation*. Participants were asked to provide the total number of positive and negative interactions they had experienced throughout the day. This approach resulted in a great number of zero values for negative interactions. When negative interactions did occur, they were infrequent, often limited to a single instance per day. This raises the question of how influential such rare events could realistically be, especially when they may have only lasted for five minutes. Future research could address this problem by shifting from frequency-based measures to other ratings of interaction quality. For instance, by asking participants how positive or negative their social interactions had been compared to their usual experiences. Alternatively, by employing more comprehensive measures of interaction quality that assess attributes such as warmth, intimacy, tension, or hostility.

Furthermore, it would have been valuable to explore positive and negative interactions separately. This could have helped determine if either type of interaction was more influential to or more easily influenced by stress. After all, it has been suggested that negative interactions have a more potent impact on well-being than positive ones (Harada et al., 2018; Lincoln, 2000; Silva et al., 2023). However, the high number of zero values for negative interactions made this approach both difficult to follow and lacking in informative value.

Another limitation concerns the absence of neutral interactions in the data. Including this category could expand the perspective on daily social interactions by providing data on how positive and negative interactions relate to the total volume of daily interactions.

In addition to these more specific limitations, it could be argued that constructing the research questions and hypotheses for this thesis after finalizing the study design limits the validity of the results, as it is non-compliant with academic standards of preregistration.

Implications and Conclusion

Due to the largely non-significant findings in this study, implications primarily concern guiding future research objectives. Some relevant directions, such as employing shorter

measurement intervals or refining the operationalization of social interactions, have already been discussed. However, one critical implication has not been addressed yet.

The findings of this investigation can be cautiously interpreted to suggest that stress reduction might exert a stronger influence on enhancing positive social interactions and reducing negative ones than vice versa. This is notable because much of the existing literature has focused on the opposite direction, i.e. how the quality of social interactions affects stress. Hence, further research should consider the directionality indicated by the present findings.

One reason the impact of stress on social interactions has been underexplored may be the perceived difficulty in addressing it. Stress often stems from systemic and societal conditions, such as pressures related to academic or workplace performance. In contrast, the maintenance of social relationships is typically considered an individual responsibility. As Rojas et al. (2025) point out, “social policy has often been conceived as a palliative measure, designed to address the social problems generated or, at best, not sufficiently addressed by pro-growth policies. […] However, these policies are far less effective when implemented within a broader and hostile socio-economic context” (Rojas et al., 2025, p. 117). Although Rojas et al. (2025) primarily focus on how these policies shape familial relationships, their argument likely applies to social connection in general. A broader socio-economic perspective should therefore be considered when designing future studies that address the relationship between stress and social interactions. Furthermore, this perspective is particularly valuable for designing effective interventions that tackle elevated stress and deficits in social connection, interventions which must consider not only individual behavior, but also the structural conditions that shape it.

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Figures

Tables

Abbreviations

AAR	Alpha-Amylase Awakening Response
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CRF	Corticotropin-Releasing Factor
DHEA-s	Dehydroepiandrosterone Sulfate
EMA	Ecological Momentary Assessment
HPA	Hypothalamic-Pituitary-Adrenal
MLM	Multilevel Modeling
PSS	Perceived Stress Scale
RQ	Research Question
SPP	Study Participant Platform
VIF	Variance Inflation Factor

Appendix

Appendix 1: Recruitment Flyer

universität wien

ProbandInnen gesucht für Studie zu „Messung von Stress im Speichel“!

Für eine psychologische Studie suchen wir aktuell gesunde Teilnehmerinnen und Teilnehmer. Die Studie untersucht die Bedeutung der Morgenaufwachreaktion von Alpha-Amylase, einem Verdauungsenzym im Speichel, das bei Stress ansteigt. Die Studie findet bei Ihnen zuhause im Alltag statt. Für die Dauer eines Monats oder eines Menstruationszyklus würden Sie innerhalb der ersten 30 Minuten nach dem Aufwachen drei Speichelproben sammeln und Fragen am Handy beantworten.

Aufwand und Entschädigung

- Für die Dauer von 30 Tagen bei Männern/einem Menstruationszyklus bei Frauen: Speichelproben (3x pro Tag) und Fragebögen (morgens und abends)
- Beantworten von Fragen zu Stress, Stimmung, Lifestyle und Menstruation.
- Aufwandsentschädigung von 100€

Teilnahmekriterien

- Regelmäßiger Menstruationszyklus, keine
- hormonelle Verhütung
- Derzeit nicht schwanger und nicht stillend
- Kein Unter oder Übergewicht , keine
- körperlichen oder psychischen Erkrankungen .
- Fließende Deutschkenntnisse
- 18 35 Jahre alt
- Kein regelmäßiger Nikotinkonsum

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Appendix 2: Abstract

Objective: Stress and social interactions are integral aspects of daily life that each exert a strong influence on mental and physical health. They are joined by a complex, and at times, obscure relationship, where one can influence the other, and vice versa, in both a beneficial and a detrimental way. This thesis examined the relationship between perceived stress and the quality of social interactions in daily life. Specifically, it explored whether stress predicts subsequent changes in the positivity and negativity of social interactions, or vice versa. *Method:* Using an ecological momentary assessment design, data were collected over 30 days for men, and over one menstrual cycle for women. Each evening, the 69 participants reported on their daily perceived stress and the daily number of positive and negative interactions, yielding 1,820 valid observations. Multilevel modeling was applied to analyze same-day and cross-day associations, while controlling for autocorrelation, gender, and long-term stress. *Results:* Higher daily stress was significantly associated with a lower same-day ratio of positive to negative social interactions. Cross-day analyses indicated no lagged effects. However, a non-significant trend suggested that higher stress might predict a lower ratio of positive to negative interactions the following day. This trend was not observed for the quality of social interactions predicting next-day stress. *Conclusion:* There was evidence for a same-day association between stress and the quality of interactions, but no temporal precedence across days. Subtle trends point toward potential delayed effects of stress on subsequent social interactions, warranting further investigation.

Keywords: perceived stress, positive social interactions, negative social interactions, ecological momentary assessment

Appendix 3: Zusammenfassung

Ziel: Stress und soziale Interaktionen sind zentrale Bestandteile des täglichen Lebens und üben jeweils einen erheblichen Einfluss auf die psychische und physische Gesundheit aus. Zwischen beiden besteht eine komplexe Wechselbeziehung, in der sie sich gegenseitig sowohl positiv als auch negativ beeinflussen können. In dieser Masterarbeit wurde der Zusammenhang zwischen Stressempfinden und der Qualität sozialer Interaktionen im Alltag untersucht. Insbesondere wurde geprüft, ob Stress Veränderungen in der Positivität und Negativität sozialer Interaktionen vorhersagt, oder umgekehrt. *Methode:* Unter Verwendung eines Ecological Momentary Assessment Designs wurden über einen Zeitraum von 30 Tagen Daten von männlichen und über einen Menstruationszyklus Daten von weiblichen Teilnehmenden erhoben. Jeden Abend berichteten die 69 Personen über ihr Stressempfinden sowie über die Anzahl positiver und negativer sozialer Interaktionen des jeweiligen Tages, wodurch insgesamt 1820 gültige Beobachtungen entstanden. Mithilfe von Mehrebenenanalysen wurden Zusammenhänge innerhalb desselben Tages sowie zwischen aufeinanderfolgenden Tagen untersucht, wobei Autokorrelation, Geschlecht und langfristiger Stress kontrolliert wurden. *Ergebnisse:* Ein höheres tägliches Stressempfinden war signifikant mit einem geringeren Verhältnis von positiven zu negativen sozialen Interaktionen am selben Tag assoziiert. In den Analysen über mehrere Tage hinweg zeigten sich keine verzögerten Effekte. Es gab jedoch eine nicht signifikante Tendenz, die darauf hindeutete, dass höherer Stress möglicherweise ein niedrigeres Verhältnis positiver zu negativer Interaktionen am Folgetag vorhersagen könnte. Dieser Trend zeigte sich nicht für die umgekehrte Richtung. *Fazit:* Es zeigte sich ein signifikanter Zusammenhang zwischen Stress und der Qualität sozialer Interaktionen am selben Tag. Eine Vorhersage über mehrere Tage hinweg war jedoch nicht möglich. Subtile Tendenzen deuten auf potenzielle verzögerte Effekte von Stress auf nachfolgende soziale Erfahrungen hin, die in zukünftigen Erhebungen weiter geprüft werden sollten.

Schlagwörter: Stressempfinden, positive soziale Interaktionen, negative soziale Interaktionen, Ecological Momentary Assessment

Appendix 4: Use of Artificial Intelligence (AI)

The author of this master's thesis declares the use of artificial intelligence tools. Specifically, StatsBot, an AI-based computer software provided by the MethodsHub at the University of Vienna, was used for the statistical analysis. In addition, Deepl (Deepl GmbH, Cologne, Germany) was used for translating between English and German, as well as for spell-checking, punctuation, and grammar. Both Deepl and ChatGPT (OpenAI, San Francisco, USA) were used to refine the language in parts of the thesis. All AI-based suggestions were re-edited and rephrased by the author after using these tools. The author therefore takes full responsibility for the content of this thesis.