

Master's Thesis

**The Association Between Gratitude and Stress in a Daily Context – An Experience
Sampling Study**

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Abstract

Background. The relationship between gratitude and stress has been gaining increasing attention because individuals with higher levels of gratefulness were shown to be better able to cope with stressful situations compared to individuals with lower levels of gratefulness (Watkins, 2004). However, although this relationship seems apparently established, no study so far investigated this association in daily life.

Objective. This study examined whether the relationship between state gratitude and state stress was a between- or within-person effect. Further, the association between state and trait gratitude was investigated, as well as between trait gratitude and trait stress.

Method. An experience sampling study was conducted for seven consecutive days among 35 students ($M_{Age} = 21.2$; 82.9% females) sampled based on convenience. In addition to the trait measures (Multi-Component Gratitude Measure (MCGM) and Perceived Stress Scale (PSS)) that were used to measure general levels of gratitude and stress, participants' state gratitude and stress were assessed three times per day using single-item questions.

Results. A multilevel linear analysis revealed a strong negative between-person association ($\beta = -.59$, $SE = .09$, $p < .001$), as well as a weaker negative within-person association ($\beta = -.29$, $SE = .05$, $p < .001$), indicating that an individual's momentary stress level largely depends on that individual's average gratitude level and to a lesser extent on that person's gratitude level at that specific moment. Further, a linear mixed model analysis displayed that individuals with higher trait gratitude tend to experience higher levels of state gratitude in their daily lives ($\beta = .44$, $SE = .05$, $p < .001$), and a linear regression analysis showed that individuals with higher trait gratitude tend to experience lower trait stress ($\beta = -.52$, $p < .001$).

Conclusion. This study provides unique insights into gratitude and stress as they naturally occur in real life, and thereby supplements and expands prior research, by highlighting that momentary levels of gratitude might operate similarly to general levels of gratitude. This supports the need for the development of individualised, timed interventions to provide individuals with suitable interventions to increase momentary gratitude when needed during daily life.

The Association Between Gratitude and Stress in a Daily Context – An Experience Sampling Study

The relationship between gratitude and stress has been gaining increasing attention due to the potential buffering effect of experiencing gratitude (Ng & Wong, 2012). For instance, individuals that feel high levels of gratefulness can better cope with stressful situations than people with lower levels of gratefulness (Watkins, 2004). However, research has not yet investigated this association in the context of daily life so far. Earlier studies predominantly examined especially gratitude as a general characteristic of individuals (e.g. Krause, 2006; McCullough, Emmons, & Tsang, 2002), and thereby neglected the fluctuating nature of emotional states. Further, most previous research on emotions and affective states in general approached these phenomena as stable and trait-like constructs. For instance, the extent to which individuals suffer from mental illnesses and are happy is generally assessed by utilising retrospective onetime questionnaires that ask the individual to think back and reconsider experienced feelings over a certain period of time. However, in this way, recollection and memory biases are introduced (Csikszentmihalyi, 2014). Moreover, various researchers have suggested a more dynamic nature of emotions, that fluctuate over time and as a response to everyday life events, and indicate that this variability cannot be assessed with a singular assessment (Kuppens, Oravecz, & Tuerlinckx, 2010). This emphasises the relevance of measuring those variables as they occur naturally in daily life, for instance by utilising the Experience Sampling Method (ESM).

Furthermore, several researchers have created interventions aimed at inducing gratitude to help individuals deal with stress (O’Leary & Dockray, 2015; Rash, Matsuba, & Prkachin, 2011). By gaining more knowledge about the association between gratitude and stress within individuals in daily life, the enhancement of existing interventions can be facilitated. Additionally, these insights can serve as a basis for the development of individualised timed interventions in order to improve treatment practices by providing individuals with suitable interventions when needed during their daily life (Schueller, Aguilera, & Mohr, 2017), thereby enabling tailored treatment that is just in time.

Gratitude

As part of the emerging interest in Positive Psychology, there is now substantial research and theory related to gratitude and its potential beneficial effects. In the literature, different conceptualisations of and approaches to gratitude appear. Approaching gratitude as a momentary level, state, or “episodes of gratitude” (Roberts, 2004, p. 59), it can be

conceptualised as “positive, social emotion experienced when an undeserved act of kindness or generosity is freely given by another person” (Rash et al., 2011, p. 351). In contrast, when considered as stable, trait-like phenomenon or the “disposition of gratitude” (Roberts, 2004, p. 59), gratitude can be defined as “generalised tendency to recognise and respond with grateful emotion to the roles of other people’s benevolence in the positive experiences and outcomes that one obtains” (McCullough et al., 2002, p. 112) and thus, rather as an individual’s characteristic, virtue (Rash et al., 2011), or affective trait (Emmons & McCullough, 2004). It was also conceptualised as a mental orientation towards the positive in one’s life (Wood et al., 2008). This enduring affective trait results in the individual’s inclination to experience gratitude more often in frequency and also in multiple contexts, as well as a lower threshold to feel grateful compared to individuals with less pronounced trait gratitude (Emmons & McCullough, 2004; Rash et al., 2011).

Cross-sectional and experimental research has found several benefits associated with experiencing state and trait gratitude, both for the individual and for society. For instance, McCullough et al. (2002) found the disposition to be grateful, thus trait gratitude, to be strongly positively correlated with positive affect and well-being. In addition to that, experiencing gratefulness is predictive of increased optimism and hope for the future (Kerr, O’Donovan, & Pepping, 2014), as well as enhanced levels of meaningfulness and meaning in life (Flinchbaugh, Moore, Chang, & May, 2011). Additionally, high general levels of gratitude were found to negatively correlate with negative affect, including anxiety and depressive symptoms (Cheng, Tsui, & Lam, 2015; McCullough et al., 2002). Moreover, feeling and expressing gratitude signifies lower stress levels (Cheng et al., 2015) and fewer negative emotions (O’Connell, O’Shea, & Gallagher, 2017).

In these previous studies, gratitude was predominantly approached as a general characteristic and its state aspect was largely neglected. Nevertheless, some researchers used the ESM to study momentary gratitude and its associations with other psychological phenomena. For example, one ESM study showed that higher momentary levels of gratitude were related to lower momentary levels of physical aggression, independently of the positive emotions the participants experienced (DeWall, Lambert, Pond, Kashdan, & Fincham, 2011). Moreover, earlier research found a strong positive association between gratitude at a general and momentary level, which indicates that individuals with high trait gratitude also experience higher levels of state gratitude in their daily lives (DeWall et al., 2011; McCullough, Tsang, & Emmons, 2004). This can be explained by the “resistance hypothesis” (McCullough et al., 2004, p. 297), which states that individuals high in trait gratitude are less dependent on daily situations

relevant for feeling grateful because their experience of gratitude is mostly driven by their personality, compared to individuals lower in trait gratitude. Therefore, individuals with lower levels of dispositional gratitude tend to experience more fluctuations in their daily grateful emotions (McCullough et al., 2004).

Additionally, in an ESM study investigating trait and state gratitude in combination with Posttraumatic Stress Disorder (PTSD), trait gratitude was found to be a significant predictor of higher daily hedonic and eudaimonic well-being for veterans with PTSD. Surprisingly, it was established that state gratitude was even more strongly related to well-being than trait gratitude, especially for veterans without PTSD (Kashdan, Uswatte, & Julian, 2006), highlighting the relevance of examining the dynamic aspects of gratitude. Further, momentary gratitude turned out to be positively related to the positive emotions cheerfulness and satisfaction (Jans-Beken et al., 2018).

In sum, previous studies suggest that gratitude is positively correlated with other positive emotions and experiences, and negatively with negative affect, over time at the micro-level of experiences in daily life. Fredrickson's "Broaden-and-Build Model of Positive Emotions" (1998) provides a framework to understand this link and how gratitude could evoke such beneficial effects. It suggests that positive emotions broaden one's momentary thought-action repertoire as well as build one's personal resources.

Stress

Research into the topic of stress has a long tradition, as stress is known for its negative implications on society, affecting individuals' physiological as well as psychological health (Glaser & Kiecolt-Glaser, 2005). It can be conceptualised as "an emotional and/or physiological response to the individual perception of a challenging stimulus" (Atz, 2012, p. 640). This highlights the apparent importance of the individual's appraisal and evaluation of a situation: stress is a highly personal and subjective experience and some people tolerate more daily life hassles or major life events than others before feeling stressed (Atz, 2012; Lazarus & Folkman, 1984). It also gives rise to individual differences and emphasises that stress can vary from day to day, from situation to situation, and should therefore be assessed and investigated as a fluctuating state, which conforms to Lazarus and Folkman's (1984) stress model. In order to better understand and find more effective strategies to cope with stress, it is important to assess it accurately by using the ESM.

Considerable knowledge has been gained about the potential impact of stress, especially when it is continuous and chronic. Nevertheless, research examining stress in daily life, which

rather involves minor hassles than major life events, is rare, even though it could contribute effectively to the development of interventions that support people in everyday life to cope with stress. Further, Vaessen, van Nierop, Reininghaus, and Myin-Germeys (2015) argue that the individual's subjective appraisal of the situation determines whether one experiences stress. However, traditional retrospective questionnaires, such as the Perceived Stress Scale (PSS) by Cohen, Kamarck, and Mermelstein (1983), measure the extent to which an individual in general appraises situations as stressful, and thus, an enduring disposition to experience stress. Individuals with high levels of trait stress compared to individuals with lower levels tend to experience more stress in their lives and have a decreased threshold to appraise a situation as stressful (Cohen, 1988). Even though several researchers acknowledge this state nature of stress, most studies approach stress at a trait level. By measuring stress as a trait-like phenomenon, the acute nature of stress is neglected and thus, fails to be assessed accordingly.

ESM studies investigating stress in association with other psychological variables confirmed the variability of stress and studying momentary stress levels in the context of ESM was validated, since stress was reinforced by experimentally inducing it (Vaessen et al., 2015). It was found that increases in perceived daily stress were related to increases in negative affect and decreases in positive affect (Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001). Further, daily stress was positively correlated with negative daily mood and trait negative affect (Marco & Suls, 1993). However, studies examining stress in the context of ESM mostly study psychiatric samples, which emphasises the importance of doing so in a healthy sample, more representative of the general population, as clinical samples were found to adapt differing coping strategies than the non-clinical population (Sadaghiani & Sorkhab, 2013).

Gratitude and Stress

Previous experimental and observational research investigating interventions aimed at enhancing gratitude suggests that especially high general levels of gratitude might enable individuals to better cope with daily stress (Southwell & Gould, 2016). For example, Cheng et al. (2015) found that counting blessings using a gratitude diary effectively reduces perceived stress among healthcare practitioners. Additionally, trait gratitude was negatively associated with perceived stress among firefighters (Lee et al., 2018).

Several possible explanations for this negative association were hypothesised in the literature, although no single reason could be determined so far. First, gratitude could serve as a protective parameter as it is predictive of increased optimism and hope for the future (Kerr et al., 2014), as well as enhanced levels of meaningfulness (Flinchbaugh et al., 2011), and this

positive mindset might buffer against becoming stressed. Second, gratitude might improve the individual's stress appraisal by enhancing one's coping resources related to social support (Cohen & Wills, 1985), since it was found to significantly contribute to the maintenance of healthy relationships as well as to the development of new relationships (Jans-Beken et al., 2019). Moreover, gratitude turned out to instigate and increase social actions in both the giver and the recipient and can therefore act as a motivator for further social actions (Rash et al., 2011) and enhance reciprocity (Nowak & Roch, 2006). Perceived greater coping resources through a supportive social environment in turn lead to lower perceived stress (Lazarus & Folkman, 1984). Third, grateful individuals possibly experience more positive emotions in general, and as positive emotions broaden one's coping resources and build other positive emotions (Fredrickson, 1998), this makes them less susceptible to experiencing stress (Folkman, 2007).

Further, Lazarus and Folkman (1984) claimed that stress is predominantly experienced when individuals evaluate a situation negatively (primary appraisal) and perceive it as exceeding one's capacity to cope (secondary appraisal). This points to the possibility to alter one's negative primary appraisal to a positive one and thereby reduce the level of stress experienced as well as decrease the demand on the individual's coping capability. Moreover, when stress is persistent and irresolvable, it was found that coping approaches aimed at promoting positive emotions, such as gratitude, are valuable (Lazarus & Folkman, 1984).

Present Research

Although the relationship between gratitude and stress seems apparently established in earlier studies, no study so far investigated the association between those constructs in daily life, outside the experimental setting, and in the context of ESM. This highlights the importance of gaining insights into the nature of those constructs and their association in the daily context, both between- and within-person, especially as it can serve as a basis for developing tailored and individualised interventions. Most prior research collects between-person data by means of cross-sectional or onetime assessments, although psychological theories often suppose intraindividual processes, and thus, another level of analysis. For that reason, longitudinal data obtained by repeated measures allow to elucidate the two levels of analysis: between-person analyses examine differences between individuals, whereas within-person analyses investigate the variability of the individual (Curran & Bauer, 2011). Therefore, this study aims to further clarify the relationship between gratitude and stress, and especially purports to find out to what extent this association is a between- or within-person association.

First, it will be examined whether the association between gratitude and stress is a between- or within-person effect. (1) *It is expected that the association between state gratitude and state stress will mainly be a strong negative between-person association, as grateful individuals were found to experience less stress.* Second, the relationship between trait gratitude and state gratitude will be investigated. (2) *It is anticipated that levels of trait gratitude will be strongly positively correlated with levels of state gratitude over time, indicating that individuals high in trait gratitude also experience greater average state gratitude due to their inclination to feel grateful.* Third, and related to the general levels of gratitude and stress, it will be explored whether the negative association that was found in prior research could be replicated. (3) *It is hypothesised that trait gratitude has a strong negative association with trait stress.*

Method

Design

The current study used the ESM, an intensive longitudinal method, which allows researchers to investigate phenomena as they naturally occur in daily life (Palmier-Claus et al., 2010). As it is a self-report diary technique with multiple brief assessments per day, it provides insight into real-life mechanisms, and enhances the ecological validity of the study as it avoids recollection and memory biases (Csikszentmihalyi, 2014; Verhagen, Hasmi, Drukker, van Os, & Delespaul, 2016). Data were collected in November 2019, using the application “The Incredible Intervention Machine” (TIIM) on the participants’ own mobile devices (“TIIM (The Incredible Intervention Machine),” 2018). The study was approved by the Behavioural, Management, and Social Sciences Ethics Committee of the University of Twente (nr. 191272). The participants took part voluntarily and gave their online informed consent before taking part.

Signal-contingent, fixed-time sampling was used for the state measurements, which means that participants received notifications for new assessments at set points in time each day (Myin-Germeys et al., 2018). Therefore, the assessments took place three times per day in time intervals of two hours (8 AM to 10 AM, 12 PM to 2 PM, 7 PM to 9 PM) for seven successive days, which resulted in 21 state assessments. Demographic data were obtained during the registration for the study and trait measurements were measured the day after the ESM part of the study ended.

Participants

Eligible participants were English-speaking students, aged 18 years or older, who owned either an Android or Apple smartphone in order to be able to download and use the TIIM

application. Participants were gathered through convenience sampling by using the Test Subject Pool System of the University of Twente (SONA) and by referral on the researchers' social media platforms.

Material and Measures

As this study was part of a greater research, the aggregated test battery also incorporated questionnaires asking for feelings of loneliness and self-compassion, as well as the social context of the participant. For the purpose of the current study, only the measures of both trait and state gratitude and stress were used.

The Incredible Intervention Machine (TIIM)

TIIM is an application for Android and IOS, developed by the University of Twente and used for questionnaire studies and group interventions. It enables researchers to construct mobile studies and is especially useful for ESM. Questionnaires are sent to the participants on predetermined times and participants receive push notifications on their smartphones whenever new questions are available, reminding them to complete the survey in the predefined time interval before it expires. In research with human subjects, data security is particularly important. For that reason, TIIM stores the data securely on the University's intern network ("TIIM (The Incredible Intervention Machine)," 2018). See Appendix A for illustrations of the application.

Trait Measures

Trait Gratitude: The Multi-Component Gratitude Measure (MCGM). For the purpose of this study, the emotional, attitudinal, and behavioural subscales of the MCGM were used. In total, the questionnaire comprised 29 items (see Appendix B), of which six measured the emotional aspect of gratitude (e.g. "I feel grateful for the people in my life"), ten assessing the attitudinal component (e.g. "I believe it is important to thank people sincerely for the help they give me"), and 13 measuring the behavioural facet (e.g. "I express thanks to those who help me"). Participants were instructed to indicate to what extent they agreed or disagreed with those items on a seven-point Likert-scale ranging from one ("strongly disagree") to seven ("strongly agree"). Ten of those items were reverse coded prior to analyses (e.g. "I don't think it is necessary to show your gratitude to others"). For analyses, the participants' total scores were calculated by adding the emotional, attitudinal, and behavioural component scores,

resulting in the total level of gratitude, ranging from 29 to 203, with higher scores signifying a higher level of trait gratitude.

The subscales of the MCGM were shown to be of acceptable to excellent reliability with Cronbach's alpha ranging from .74 to .92 (Morgan, Gulliford, & Kristjánsson, 2017). Further, the hierarchical structure of trait gratitude constituting multiple components was confirmed in earlier research (Morgan et al., 2017). Analyses of the current sample revealed a Cronbach's alpha of .87, which points to good internal consistency for the total scale (Blanz, 2015).

Trait Stress: Perceived Stress Scale (PSS). The PSS (see Appendix C) measures the degree to which individuals perceive situations in their lives as stressful (Cohen et al., 1983). The ten-item version was used since its psychometric properties were shown to be superior to the other versions (Lee, 2012). Participants were invited to rate how often they felt or thought in a certain way in the last month on a four-point Likert-scale, ranging from zero ("never") to four ("always"). Six of those questions were negatively stated (e.g. "In the last month, how often have you felt nervous and "stressed"?"). The remaining four items were positively stated and needed reverse coding (e.g. "In the last month, how often have you felt confident about your ability to handle your personal problems?") and total scores were then computed by summing all items. This resulted in a continuous range of scores from zero to 40, with higher scores indicating higher levels of perceived stress. The PSS was found to have acceptable to excellent internal reliability and satisfactory test-retest reliability (Lee, 2012). For this study, Cronbach's alpha equalled .89, which represents good internal consistency (Blanz, 2015).

State Measures

The daily state measures were randomly arranged in each assessment to prevent habituation and ordering effects. As the state measures were assessed three times daily, they were kept as short as possible, since ESM assessments should not take the participants more than two minutes to complete in order to minimise participant burden (Myin-Germeys et al., 2018), which increases participant motivation and response rates.

State Gratitude. State gratitude was assessed with a single item ("I am grateful right now") on a seven-point Likert-scale ranging from one ("strongly disagree") to seven ("strongly agree"), similar to measures used in other ESM studies (e.g. Cox et al., 2018). A linear mixed model analysis (as explained in *Results*) revealed a significant and moderate positive association between trait gratitude and state gratitude and therefore, suggests that the state assessment of gratitude was a valid measure of momentary levels of gratitude.

State Stress. State stress was also measured with a single item (“On a scale from one to seven, and seven being the worst stress possible, what number best describes your level of stress right now?”) derived from the Stress Numerical Rating Scale-11 (SNRS-11), which is an instrument that was shown to have moderate to strong construct validity (Karvounides et al., 2016). A linear mixed model analysis (as explained in *Results*) indicated a significant, and moderate positive association between trait stress and state stress, and thus, reveals that the single item was also a valid measure of momentary levels of stress.

Procedure

During the set-up of the study, individual questions were repeatedly checked for their functionality within the TIIM application and adapted accordingly. Before starting the survey, pilot tests were conducted with two participants to check the user interface, the timing of the application, and its functionality by responding to items, as proposed by Conner and Lehman (2012).

In order to take part in the survey, participants had to register with their email addresses and choose a password, before indicating their demographic information, such as age, gender identity, nationality, and student status. Following that, they were provided with the invitation to download and install the TIIM application using a link to the Google Play Store for Android and to the Apple Store for iOS, respectively, and log in with their chosen credentials. Further, they were informed that the survey part of the study would start the next day. One day prior to the outset of the study, participants were briefed about the research in order to prepare them for the assessments, which is especially important in ESM studies, as the participants conduct the study without researchers being present for additional questions (Palmier-Claus et al., 2010). The briefing involved information about the research background, how often they could expect the measurements, and about their rights, that participation was voluntary, and they could stop their participation without giving a reason at any time. Moreover, participants had to actively agree to the online informed consent for participation.

During the subsequent seven days, the participants received three identical assessments per day. The assessment moments were scheduled in time intervals of 8 AM to 10 AM, 12 PM to 2 PM, and 7 PM to 9 PM to get insight into real-life states and capture the different settings individuals experience during daily life (Palmier-Claus et al., 2010). As the daily questionnaires consisted of only five items in total, it took participants about a minute to complete each assessment and therefore reduced interruptibility and participant burden (Conner & Lehman, 2012). Each item was required to be answered before the next one was accessible to avoid

unintentional loss of data. Moreover, participants should have received push notifications on their smartphone whenever a new assessment was available, which aimed to reduce participant burden (van Berkel, Ferreira, & Kostakos, 2017). Due to technical issues of the application, this did not work automatically and thus, the four participants that registered first were requested to arrange individual alarms intended to remind them to complete the state assessments. Nevertheless, low response rates revealed that this method did not work as planned, presumably because participants either did not set the alarms or because of ignoring them. Therefore, the researchers sent manual reminders as push notification which led to higher response rates. Further, they observed the response rates in the time intervals, and if they detected individuals who did not complete the assessment 30 minutes before the end of the interval, they sent additional reminders. The schedule of push notifications can be found in Appendix D.

The next day following the week of ESM assessments, the participants received the trait questionnaires mentioned in *Materials and Measures* at 8 AM. All items needed to be completed before another questionnaire was available.

Students of the University of Twente that registered for the study via the Test Subject Pool System of the University of Twente were rewarded with 2.5 research credits for taking part in order to increase motivation to comply despite the participant burden (Conner & Lehman, 2012).

Data Analyses

The data were exported as CSV file from the TIIM application and imported into SPSS. For all statistical analyses, SPSS version 26.0 and two-tailed tests with a significance level of $< .05$ were used. Excel was utilised for graphical illustrations by means of line graphs. Prior to analyses, the dataset needed preparation and adjustment to fit the analyses. The two datasets were merged in order to obtain one dataset containing both state and trait measurements and then modified into a long data format. Individuals that did not complete all assessments (response rate $< 100\%$) were excluded from analyses. Further, the total level of trait gratitude was created by computing a new variable adding up the emotional, attitudinal, and behavioural components of gratitude.

Descriptive statistics in form of means and standard deviations were calculated to get insight into the participants' demographic data as well as their baseline characteristics, such as trait stress and trait gratitude. Further, person means (PM) and person mean-centred scores (PM-centred) for state gratitude and state stress were computed (Curran & Bauer, 2011). PM scores reveal the average state gratitude and stress levels per participant across all timepoints

and allow for between-person analyses, while PM-centred scores reflect momentary deviations in state gratitude and stress of all persons per timepoint, signifying how much the state gratitude and stress level at each timepoint differ from the PM and thus, enables within-person analyses. Moreover, boxplots were generated for graphical illustrations of each participant's fluctuations in state gratitude and state stress over the study period (Curran & Bauer, 2011).

For all state and trait variables, z-scores were computed in order to obtain standardised estimates, which allowed to compare them. Therefore, the following analyses were conducted using the standardised scores, which resulted in standardised estimates. The ESM data consist of two levels of information: state gratitude and state stress (Level 1) for each individual (Level 2). Due to the longitudinal and nested nature of the ESM data, multiple linear mixed model (LMM) analyses with an autoregressive covariance structure (AR1) were conducted.

First, in order to examine whether the relationship between state gratitude and state stress was a momentary (within-person) or a general (between-person) one, a multilevel linear model analysis was performed using state stress as dependent variable and both PM-centred (within-person) scores and PM scores (between-person) for state gratitude as fixed covariates.

Moreover, the association between trait gratitude and trait stress was investigated by a linear regression analysis, with trait stress as dependent and trait gratitude as independent variable. For assessing the validity of the state measurements, the association between trait stress and state stress, as well as between trait gratitude and state gratitude were examined, using two further LMM analyses. The trait measures were set as fixed covariates and the PM scores of the state measures as dependent variables.

In order to calculate the reliability of the state measures and thus, the stability of responses, the longitudinal dataset was split into halves and mean scores between the first and second half of the data timepoints were compared using Pearson correlation analyses, as suggested by Palmier-Claus et al. (2010). The answers were also split based on odd and even numbers of the timepoints, in order to obtain two correlation coefficients per construct and thus, improve the conclusion about the stability of responses. A Pearson coefficient r of $> .1$ ($-.1$) was assumed a weak association, $> .3$ ($-.3$) indicated a moderate correlation, and $> .5$ ($-.5$) was considered a strong correlation (Cohen, 1988).

Results

Participant Flow

Overall, 59 individuals agreed to take part in the study. As the concerned data was from a previously acquired dataset, some of the reasons why participants were excluded as well as

the exact numbers were unknown. Nevertheless, participants using an Apple device were prevented from participating due to the technical incompatibility of the iOS system with the TIIM application at the time of data collection. Additional participants were removed because they did not complete the trait measures and thus, could not be included in the analyses. Lastly, individuals that did not complete all state measurements were eliminated, which resulted in a total of 35 participants that were included in the analyses.

Descriptive Statistics

The participants' ages ranged from 18 to 40 ($M = 21.2$, $SD = 4.51$). 82.9% of the participants identified as female, 11.4% as male, 2.9% as transgender, and 2.9% as gender variant/non-conforming. Individuals from different nationalities took part, with the majority being of German (48.6%) or Dutch (40%) nationality, but also individuals of Bulgarian, Indian, Indonesian, and Vietnamese (each 2.9%) nationality participated.

In total, 735 state assessments were completed. Descriptive data on the trait measures are provided in Table 1. Compared to the age-related norms (age-group 18-29, because $M_{age} = 21.2$) presented in Cohen, Kamarck, and Mermelstein (1983), participants scored in a normal range in trait stress. For the MCGM, norm tables were not available. The total sample seemed to be rather grateful, as the total gratitude minimum score of 104 signifies an average level of trait gratitude.

Table 1

Minimum, maximum, means, and standard deviations for the trait measures in the final sample

Variable	Minimum (Scale Minimum)	Maximum (Scale Maximum)	Total (N = 35) $M (SD)$
Trait stress	5 (0)	36 (40)	15.51 (6.55)
Trait gratitude	104 (29)	180 (203)	144.94 (16.91)
Emotional gratitude	18 (6)	42 (42)	33.63 (6.03)
Attitudinal gratitude	41 (10)	66 (70)	51.46 (5.49)
Behavioural gratitude	42 (13)	81 (91)	59.86 (10.39)

In general, the participants encountered considerable variability in their experiencing of gratitude and stress during the study period (Figure 1 and 2), which indicates that participants tend to differ in these affective states. As can be seen, there was substantial fluctuation both within-persons and between-persons. Overall, the mean score in the total sample for state

gratitude was higher than for state stress. This tendency of experiencing higher momentary levels of gratitude than of stress is also visible looking at individual scores (Figure 1 and 2).

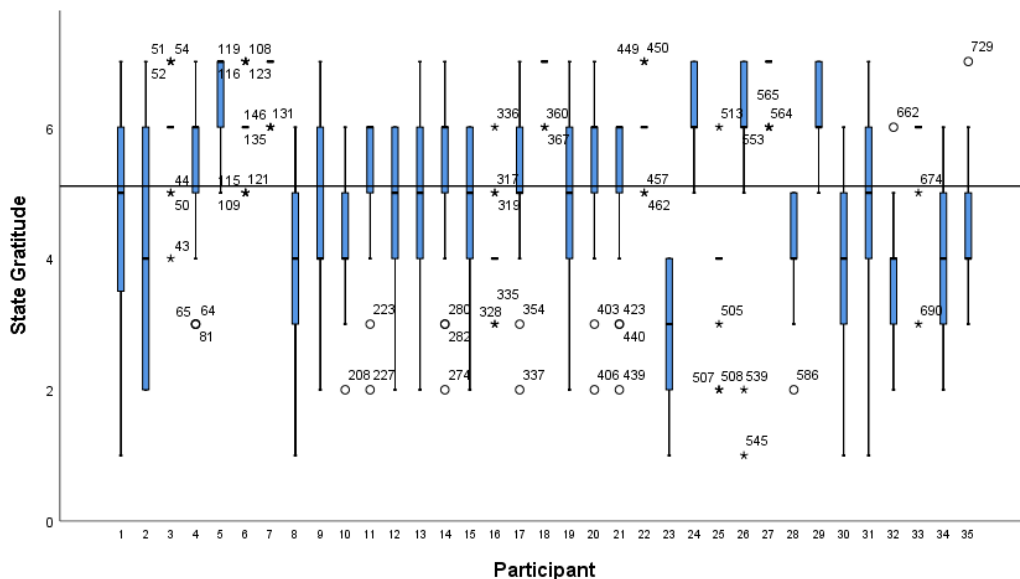


Figure 1. Boxplot depicting the variation in experiencing gratitude for each participant with a reference line set at the group mean ($M = 5.1$).

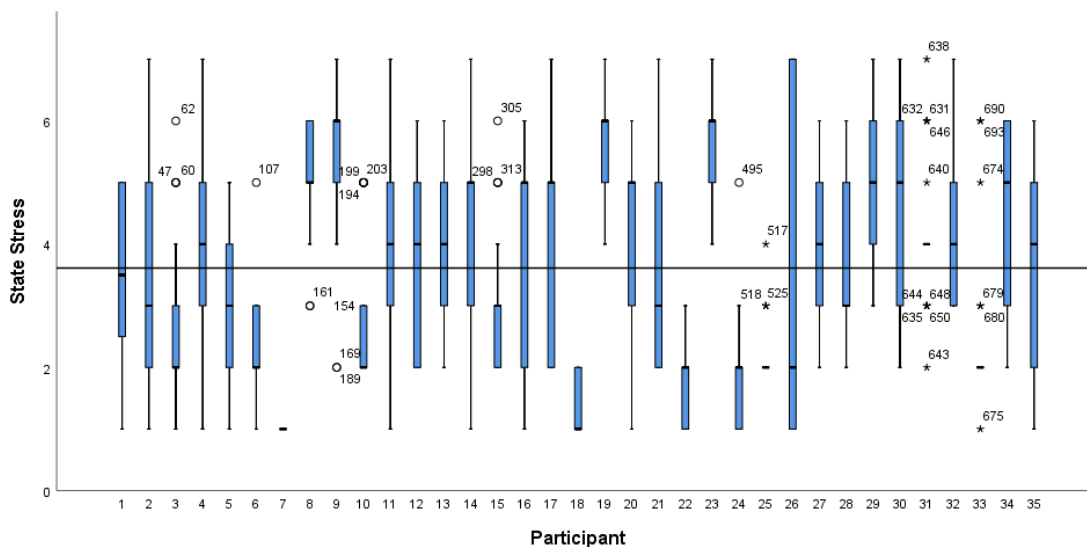


Figure 2. Boxplot depicting the variation in experiencing stress for each participant with a reference line set at the group mean ($M = 3.61$).

Reliability Assessment

Stability of Responses

The obtained scores on state stress and state gratitude were split into half at the twelfth timepoint in order to compare the first and second half of the data collection, as well as based

on odd and even numbers of timepoints. Pearson correlation analyses indicated significant, moderate positive correlations between the scores for gratitude (first and second half: $r = .37$, $p < .001$; even and odd numbers: $r = .48$, $p < .001$). In contrast, the correlations between the scores for stress were opposing: whereas one method of splitting revealed no association (first and second half: $r = 0$, $p = .971$) with significantly greater average state stress in the second half of data collection, the other method of splitting showed a significant, and moderate positive association (even and odd numbers: $r = .43$, $p < .001$).

Variability

Linear mixed model analyses indicated that there was a significant positive linear effect between state stress and time ($\beta = .02$, $SE = .02$, $p = .05$), as well as between state gratitude and time ($\beta = .01$, $SE = .01$, $p = .009$).

Validity Assessment

Linear mixed model analyses were conducted to determine whether the trait measurements were significant covariates for the state measurements. Trait stress was found to be a significant covariate for state stress ($\beta = .38$, $SE = .05$, $p < .001$; see Appendix E, Figure 3), and trait gratitude was found to be a significant covariate for state gratitude ($\beta = .44$, $SE = .05$, $p < .001$; see Appendix E, Figure 4). These moderate positive associations between the trait and state assessments indicate that individuals with higher levels of trait stress tend to also experience higher levels of state stress and vice versa, and individuals that have higher levels of trait gratitude experience higher levels of state gratitude and vice versa.

State Gratitude and State Stress

It was examined whether state stress depends on state gratitude levels at a specific timepoint (within-person, PM-centred) or on average state gratitude levels (between-person, PM). It was found that PM-centred state gratitude scores significantly predicted state stress, $F(1, 632.38) = 78.99$, $p < .001$, and PM state gratitude scores also significantly predicted state stress, $F(1, 142.19) = 45.29$, $p < .001$. The results revealed a significant, strong and negative between-person association ($\beta = -.59$, $SE = .09$, $p < .001$; see Appendix, Figure 5), as well as a significant, but weaker negative within-person association ($\beta = -.29$, $SE = .05$, $p < .001$) between state gratitude and state stress. This indicates that the negative association between state gratitude and state stress mainly is a between-person, trait-like effect, rather than a within-

person, state-like effect. Therefore, a person's momentary stress level largely depends on that person's average gratitude level and to a lesser extent on that person's gratitude level at that specific timepoint.

Individual Cases for Visualisation

Individual participant data were outlined to display the experiences of gratitude and stress over the course of the study period, depicting individuals with differing trait gratitude and trait stress levels.

Participant 8. Participant 8 scored low on trait gratitude (134), and high on trait stress (23). The individual experienced – in contrast to the total sample – higher stress ($PM = 4.95$) than gratitude levels ($PM = 3.86$). Further, this individual shows high fluctuations in gratitude (Figure 6), ranging from one (not at all grateful) to six (grateful), and is more stable in stress, ranging from three (not highly stressed) to six (stressed). During most measurement moments (e.g. 4, 10, 12), a strong negative association can be seen, in which he experienced mainly high stress levels while low gratitude levels, or increased gratitude levels and decreased stress levels.

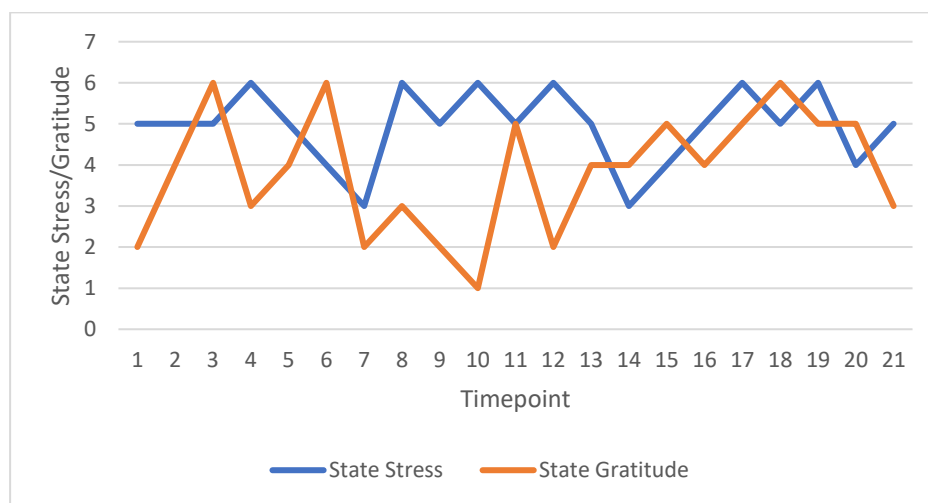


Figure 6. Line graph depicting state stress and gratitude levels per timepoint of participant 8.

Participant 19. Participant 19 scored average on trait gratitude (141), on average state gratitude levels ($PM = 5.1$), as well as on trait stress (21). This participant experienced high fluctuations primarily in gratitude (Figure 7), ranging from two (not grateful) to seven (highly grateful), and varied slightly less in stress, from four (neutral) to seven (highly stressed). In some occasions (e.g. timepoint 5, 9, 16), a mostly weak negative association is visible, whereas in another occasion (e.g. 13), a positive association can be seen. Nevertheless, for most timepoints, gratitude and stress seem not greatly associated.

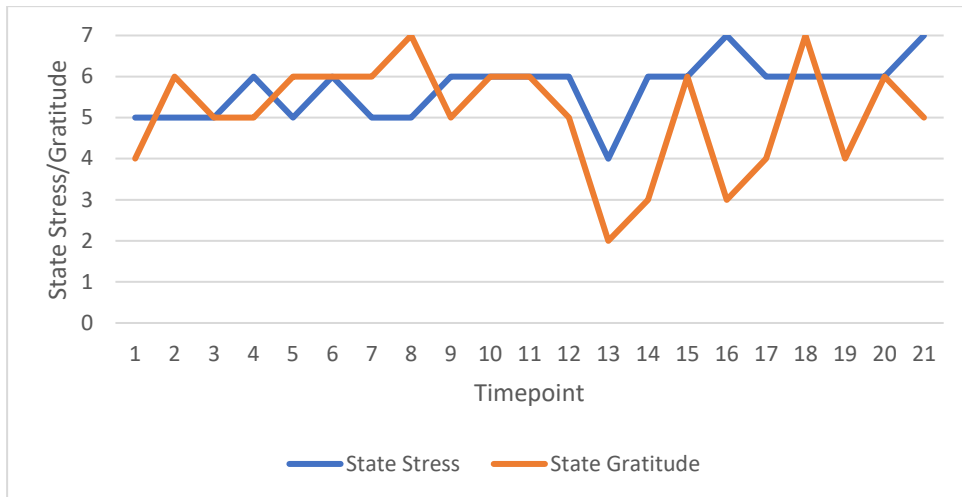


Figure 7. Line graph depicting state stress and gratitude levels per timepoint of participant 19.

Participant 3. This participant is highly trait grateful (157) and low trait stressed (13). Although this individual experienced variability, the range was much smaller compared to other participants. For several timepoints, a positive association between gratitude and stress can be seen (Figure 8), in which gratitude and stress levels simultaneously increased (e.g. 3, 14, 18) or decreased (e.g. 2, 4, 15, 19).

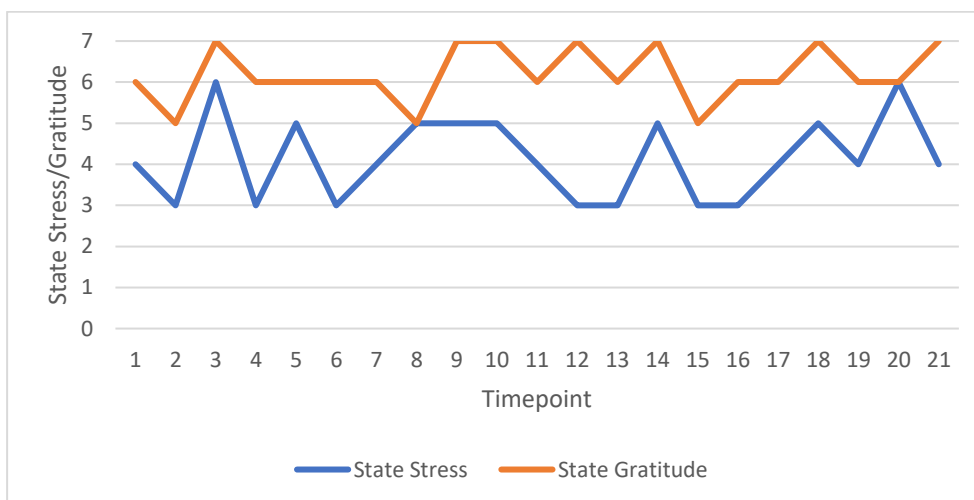


Figure 8. Line graph depicting state stress and gratitude levels per timepoint of participant 3.

These examples suggest that the found negative within-person association between gratitude and stress differs between persons as well and is evident in various degrees. Whereas for one individual, a strong negative association was found for most of the timepoints, for another individual, a positive association was visible.

Trait Gratitude and Trait Stress

The expected negative association between trait gratitude and trait stress was examined using a linear regression analysis. To assess linearity, a scatterplot of trait stress against trait gratitude with superimposed regression line was plotted and visual inspection of these plots indicated a linear relationship between these variables. Homoscedasticity and normality of the residuals were confirmed, and no outliers were observed. Trait gratitude statistically significantly predicted trait stress, $F(1, 733) = 269.28, p < .001$, accounting for 26.9% of the variation in trait stress with adjusted $R^2 = 26.8\%$, implying a medium effect size (Cohen, 1988). Further, trait gratitude and trait stress were significantly and strongly negatively correlated ($\beta = -.52, p < .001$), which underlines that an individual with high trait gratitude tends to have low trait stress and vice versa (see Appendix E, Figure 9).

Discussion

The purpose of this study was to investigate the relationship between gratitude and stress in the context of daily life. More specifically, it was examined whether gratitude and stress were negatively correlated and whether the association between momentary levels of gratitude and of stress was a between- or within-person effect. There are three key findings of the current research. First, the results provide supporting evidence that the negative association between state stress and state gratitude primarily is a between-person rather than a within-person effect. This implies that an individual's level of momentary stress depends predominantly on that individual's average gratitude level and to a lesser extent on that individual's gratitude level at the specific timepoint. Second, this study replicated the finding that trait gratitude and state gratitude are positively associated, indicating that individuals with higher general levels of gratitude tend to experience also higher levels of momentary gratitude (DeWall et al., 2011; McCullough et al., 2004). Third, in line with the expectations, it was found that general levels of gratitude are strongly negatively correlated with general levels of stress, which means that individuals with higher trait gratitude undergo lower trait stress levels and vice versa (Nezlek, Krejtz, Rusanowska, & Holas, 2018).

Interpretation of Results and Theoretical Reflection

Gratitude

The current study provides support for the hypothesis and replicated the finding that individuals who show high dispositional gratitude also tend to show higher levels of state gratitude, which conforms to one of the aspects of what McCullough et al. (2002) named the

“facets of the grateful disposition”: dispositional grateful individuals feel gratitude more often in frequency. This can be due to their lower threshold of experiencing gratitude (DeWall et al., 2012), or due to the increased intensity of felt gratitude, the greater span – feeling grateful for several aspects in life – or the expanded density – the number of individuals one feels grateful for (McCullough et al., 2002). Further, this finding can be explained by the “Broaden-and-Build Theory of Positive Emotions” (Fredrickson, 1998): experiencing the positive emotion of gratitude broadens by initiating the impulse to savour one’s circumstances, and generates customary ways of thinking, for instance about the things one is grateful for. Further, experiencing gratitude instigates and increases social actions in both the giver and the recipient and can act as a motivator for further social actions (McCullough, Kilpatrick, Emmons, & Larson, 2001; Rash et al., 2011), which in turn stimulates gratefulness in the opposite (Nowak & Roch, 2011), thereby setting an upward spiral of prosocial behaviour and enhanced well-being into motion (Nowak & Roch, 2006; Watkins, 2004).

Nevertheless, the association between trait and state gratitude was, only partly in line with the expectations, only moderately positive. This can be explained by Zuckerman (1979) who argued that traits are more than just averaged states and both constructs measure distinct phenomena. This relates to the point that other researchers made, that one’s traits influence states in combination with situational and environmental factors, and thus, there are other aspects affecting one’s emotional states (Matthews, Deary, and Whiteman, 2003). Matthews et al. suggested that the correlation between trait and state measures should only be small to moderate (2003), and therefore, the pattern of this study’s results is consistent with that claim.

Gratitude and Stress

Gratitude and stress were also investigated jointly in the context of daily life. It was examined whether their negative association that was found in prior research (Southwell & Gould, 2016) could be replicated and whether this association was a between- or within-person effect.

Between-Person Association. It was found, as anticipated, that there was a significant negative between-person association between gratitude and stress. That means that individuals with higher (or lower) state gratitude levels on average compared to others experience lower (or higher) state stress levels. This pattern of results is in line with the study of Wood et al. (2008), who discovered that dispositional gratitude naturally results in lower levels of stress. These researchers further claimed this relationship to be both a direct one as well as an indirect one – via the increase of enhanced social support and higher levels of appraisal (Wood et al.,

2008). This finding can also be explained by the “Broaden-and-Build Model of Positive Emotions” (Fredrickson, 1998), which proposes that positive emotions, such as gratitude, can “undo” the implications of experiencing negative emotions, such as stress (Sztachañska, Krejtz, & Nezlek, 2019). Moreover, Vernon, Dillon, and Steiner (2009) found gratitude to be linked to proactive coping strategies that help to deal with stressful situations.

Concluding, there are two possible interpretations of this finding. First, being a generally grateful person involves a stable inclination to experience gratitude (Okely, Weiss, & Gale, 2017) and thus, positive emotions, which might buffer against experiencing high momentary stress. Second, grateful individuals tend to use more adaptive coping strategies and therefore, have a higher threshold to feel stressed (Wood et al., 2008).

Within-Person Association. The present results also imply a significant negative within-person association between gratitude and stress, which indicates that in moments that individuals experience higher (or lower) levels of gratitude compared to their average, they experience lower (or higher) stress levels at that moment as well. One interpretation for this finding is that experiencing high stress in a situation might dampen feelings of gratefulness, especially for individuals with rather low general levels of gratitude (Algoe & Stanton, 2012). These individuals only experience gratitude when they evaluate the situation as positive and valuable (McCullough et al., 2002), and as a result, would have difficulties finding something or someone to feel grateful for in stressful situations. This would be in line with the “Stress-Buffering Hypothesis” (Okely et al., 2017, p. 53), which proposes that positive emotions and social support can shield against stress. Nevertheless, Vernon, Dillon, and Steiner (2009) discovered that some individuals undergoing trauma can enhance their gratitude levels during times of high stress. Since high dispositional gratefulness involves positive biases in understanding one’s environment (Wood et al., 2008), those individuals could even benefit from experiencing momentary stress, as they have learned how to generate gratitude and might be able to increase their grateful feelings by finding positivity in stressful situations. However, the latter would implicate a positive within-person association between gratitude and stress, which is contrary to the current study’s overall findings. Surprisingly, this positive association was found for a high trait grateful and low trait stressed participant, who felt grateful (or not grateful) and stressed (or not stressed) at the same time and experienced only few fluctuations in grateful feelings. As mentioned above, high trait grateful individuals tend to experience higher state gratitude as well and also have more stable state gratitude levels, compared to low trait grateful individuals that fluctuate much more, as evident when looking at individual participants, which is in line with previous research (McCullough et al., 2004).

These results support the use of gratitude interventions aimed at inducing or enhancing state gratitude. Previous research provided evidence for the short-term effectiveness of gratitude interventions to reduce stress using Randomised Controlled Trials (Cheng et al., 2015; O’Leary & Dockray, 2015; Southwell & Gould, 2016), as well as a longitudinal study (Killen & Macaskill, 2014). The finding that there is also a significant negative within-person association between gratitude and stress proposes that these interventions might even have longer-lasting effects.

Taken together, the results demonstrate both a significant negative between- and within-person association between gratitude and stress. Nevertheless, the between-person association was higher, which indicates that an individual’s momentary stress level predominantly depends on that individual’s average gratitude level and only to a lesser extent on the gratitude level at the specific moment. Therefore, interventions tackling both general and momentary gratitude might be beneficial and effective for individuals undergoing stress.

Further Findings

Overall, as expected, the results indicate that individuals considerably varied in their experiencing of gratitude and stress, which is in accordance with other ESM studies (Kashdan & Steger, 2006; Versluis et al., 2018) and provides evidence for the fluctuating nature of emotional states. There was both substantial within- and between-person variability. Nevertheless, as this study did not investigate the participants’ situational or environmental context during the measurement moments, individual reasons for these variations cannot be presented and need further examination. In general, the participants experienced higher momentary levels of gratitude than of stress, which is in line with the findings of Zelenski and Larsen (2000). They established that participants’ moods were dominated by positive emotions, such as happiness and relaxation, in contrast to negative emotions like anger and disgust. In this regard, the current sample may not be representative of the general population, as students were found to vary predominantly randomly from the general public (Hanel & Vione, 2016). Therefore, the experience of higher levels of gratefulness compared to stress levels in the current study could be due to the privileged sample.

Further, the current research implicates that ESM is a suitable method to investigate the dynamic nature of the experience of gratitude and stress, as it generates insights into the fluctuations that participants underwent over the course of seven days. It was established that the measures of momentary levels of gratitude and stress correlated with their corresponding measures of general levels of these experiences, even though this relationship was only

moderate. This indicates, that studying these affective states in the context of daily life provides considerable insight into the variability of emotions, that one-time administered measurements of traits cannot account for (Trull & Ebner-Priemer, 2009).

Lastly, the results of the current study provide support for the hypothesis that trait gratitude and trait stress are negatively correlated, indicating that individuals with a high (or low) general level of gratitude tend to experience low (or high) general levels of stress. Further, the found negative relationship was strong and thus, is in line with the expectations. This pattern of results is consistent with prior studies, such as the work from Lee et al. (2018), who found that gratitude was strongly negatively associated with stress and suggested that this can be explained by the protective function that gratitude fulfils against stress. Nevertheless, most previous work associating stress with gratitude – especially examining trait aspects – has been correlational or experimental, and thus, comparable research is scarce.

Concluding, the current study supplements and expands prior research investigating gratitude by highlighting that momentary levels of gratitude might operate similarly to general levels of gratitude. Like the negative association between trait gratitude and trait stress, this study revealed a negative between- and within-person association between their state counterparts.

Strengths and Limitations

This study contributes to the literature about gratitude and stress, especially in the context of daily life. A first advantage is that this study is the first to assess both gratitude and stress using the ESM and thereby provides unique insights into how individuals experience these affective states in real-life. A further asset concerns its methodological nature: the ESM in general enhances ecological validity (Verhagen, et al., 2016), as well as construct and external validity (Trull & Ebner-Priemer, 2009) by assessing participants in their daily life and thereby providing insights into naturally occurring experiences. Therefore, the extent to which this study's findings can be generalised to the real-life context is increased. Additionally, the ESM allowed to investigate not only between-person but also within-person associations, which is a unique feature of this method compared to cross-sectional studies (Csikszentmihalyi, 2014).

Another strength regards the used trait and state measures and their psychometric properties. The reliability for both trait assessments was good, indicating high levels of internal consistency for those scales in this sample, supporting previous findings analysing these measures (Lee, 2012; Morgan et al., 2017). Further, the reliability assessments of the state measures revealed moderate to strong correlation coefficients for the state gratitude measure,

thereby underlining its reliability. Regarding the reliability of state stress, the conclusions must be drawn with caution: the correlation coefficient based on the splitting between odd and even timepoints represent good reliability, whereas the correlation coefficient based on the splitting between the first and second half of data collection displayed no correlation and significantly greater average state stress in the second half. This change might be attributed to the monitoring and reporting of stress in the study period which could have changed the participants' behaviours (measurement reactivity), to an alteration of their understanding of the item, or to differences in engagement in the study (Palmier-Claus et al., 2010). Especially for avoiding measurement reactivity, future research should make use of random-time sampling, as it is less predictable than the fixed-time sampling applied in this study (Verhagen et al., 2016). Nevertheless, the state measures were found to be valid assessments, as they were moderately and positively associated with the according trait assessments, which is in line with previous findings (Matthews et al., 2003).

Nevertheless, this research also has shortcomings. First, technical issues hindered the planned disappearance of the state assessments after the time interval has ended (after two hours). That means, that the questions programmed to be answered in the morning or afternoon could have been completed at the end of the day, and participants might have indicated their momentary levels of gratitude and stress at that point, and thereby affect the study's ecological validity. Further, the ESM does not allow for drawing conclusions concerning causality, as there could be potential confounding variables accounting for the results. Therefore, additional, and more elaborate research of experimental nature is needed to investigate the processes underlying the fluctuation in affective states and the association between gratitude and stress.

Moreover, the sample and sampling strategy of this study is problematic and could have been improved, since only university students took part that were sampled based on convenience, which resulted in an overrepresentation of females (82.9%), as well as higher educated individuals. This could implicate higher state stress levels due to educational activities and examinations, or even lower stress levels because of more time for recreational activities than employees. Another limitation regards the use of single-item measures as state measures. Even though validity assessments of these state measures revealed correlations with the respective trait measures, these were only moderate. That means, that its validity might be questionable, which can be explained by the utilisation of only one question each time in order to decrease participant burden and interruptibility (Conner & Lehman, 2012), which generally presents an issue related to validity. However, it could also point to the possibility, that state and trait assessments simply measure different construct because of their different approaches.

Future Research

In order to address these limitations, future research should conduct a more elaborate pilot test in which technical capabilities of the application are tested adequately before starting the study, which would make it more robust against threats concerning its ecological validity and technical issues. Moreover, further research should investigate other sections of the population and make use of larger samples to test whether the same results would hold true for differing samples and to draw more powerful inferences about the data. Additionally, other dynamics might be interesting to capture, for instance, assess momentary stress levels some time before gratitude to obtain insights into how grateful feelings might change when having felt stressed shortly before, which allows for time-lagged analyses. Additionally, for further analyses, participant data should be organised into groups (high, average, and low in average gratitude levels) to assess within-person associations based on averaged gratitude levels.

In general, the current research can serve as a basis for Ecological Momentary Interventions (EMIs), which can enhance the revolution of treatment practices (Schueller, Aguilera, & Mohr, 2017) by shifting treatment from the clinical context into daily life and by providing individualised on-time interventions. That means, that tendencies to experience greater momentary levels of stress can be detected early in time and interventions aimed to increase momentary levels of gratitude would be provided in order to buffer the experience of stress and its consequences, thereby allowing for more effective coping strategies. EMIs can also improve individual's encouragement, motivation, and compliance, and reduce disruptions in their daily life, as individuals keep their smartphone continually in their close proximity (Schueller, Aguilera, & Mohr, 2017). Further, the high numbers of individuals experiencing stress (Mirzaei, Ardekani, Mirzaei, & Dehghani, 2019) combined with a lack of healthcare opportunities, make cost-effective treatments a pressing issue.

Conclusion

Since most research so far approached gratitude and stress as trait-like and stable phenomena and thereby neglected the fluctuating nature of affective states, this study provides important insights into those constructs and especially into their association in real-life. It was replicated, that individuals high in trait gratitude also tend to experience greater state gratitude in their daily lives. Further, this study established both a negative between- and within-person association between gratitude and stress. Although the between-person association was stronger, the results support the need for the development of EMIs in order to improve individuals' gratitude and their coping with stress.

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Appendices

Appendix A – The Incredible Intervention Machine (TIIM)

Subscription and Demographic Questions.

<p>Welcome!</p> <p>Welcome to our survey!</p> <p>We are glad to see you here!</p> <p>Please, register with a valid e-mail address and choose a password that you will <i>remember!</i></p> <p>Do NOT enter any name!</p>	<p>← Welcome!</p> <p>Please enter your emailaddress to continue</p> <p>emailaddress</p> <hr/> <p>Firstname</p> <hr/> <p>Lastname</p> <hr/> <p>password</p> <hr/>	<p>← Welcome!</p> <p>How old are you?</p> <p>type your answer here</p> <hr/>
<p>< BACK CONTINUE ></p>	<p>< BACK CONTINUE ></p>	<p>NEXT QUESTION ></p>
<p>← Welcome!</p> <p>To which gender identity do you most identify?</p> <ul style="list-style-type: none"> <input type="checkbox"/> Female <input type="checkbox"/> Male <input type="checkbox"/> Transgender Female <input type="checkbox"/> Transgender Male <input type="checkbox"/> Gender Variant/Non-Conforming <input type="checkbox"/> Prefer Not to Answer 	<p>← Welcome!</p> <p>What is your nationality?</p> <p>type your answer here</p> <hr/>	
<p>< PREVIOUS QUESTION NEXT QUESTION ></p>	<p>< PREVIOUS QUESTION NEXT QUESTION ></p>	

Appendix B – The Multiple-Component Gratitude Measure (MCGM)

(* Reverse Scored Item.

Emotional Component of Gratitude

Feelings of Gratitude.

1. There are so many people that I feel grateful towards.
2. There are so many people that I feel grateful for.
3. I feel appreciative of the support of many people in my life's journey.
4. I feel grateful for the people in my life.
5. Thinking about all I have to be grateful for makes me feel happy.
6. There are many things that I am grateful for.

Attitudinal Component of Gratitude

Attitudes to Appropriateness.

7. Gratitude should be reserved for when someone does not want anything in return. (*)
8. Gratitude should be reserved for when someone intends to benefit you. (*)
9. I only show gratitude to people who have benefitted me without wanting anything in return. (*)
10. I only show gratitude for the things that are not already due to me/are mine by right. (*)
11. I only show gratitude towards people who clearly intended to benefit me. (*)
12. I only feel grateful when the benefit is of genuine value to me.

Attitude of Gratitude.

13. I don't think it is necessary to show your gratitude to others. (*)
14. I believe it is important to thank people sincerely for the help they give me.
15. I believe gratitude is an important value to have.
16. It is important to acknowledge the kindness of other people.

Behavioural Component of Gratitude

Behavioural Shortcomings.

17. I forget to let others know how much I appreciate them. (*)
18. I forget to reflect on the things that I am grateful for. (*)
19. I overlook how much I have to be grateful for. (*)
20. I forget to remind myself that there is so much in life to be thankful for. (*)

Rituals/Noticing Benefits.

21. I stop to recognise all the good things I have in my life.
22. I recognise how many things I have to be grateful for.
23. I stop and think about all the things I am grateful for.

- 24. I reflect on all the good things I have.
- 25. I remind myself of the benefits I have received.

Expressions (of Gratitude).

- 26. I make it a priority to thank others.
- 27. I express thanks to those who help me.
- 28. I notice the people who are kind to me.
- 29. I go out of my way to thank others for their help.

Appendix C – Perceived Stress Scale (PSS)

(*) Reverse Scored Item.

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate how often you felt or thought a certain way.

1. In the last month, how often have you been upset because of something that happened unexpectedly?
2. In the last month, how often have you felt that you were unable to control the important things in your life?
3. In the last month, how often have you felt nervous and “stressed”?
4. In the last month, how often have you felt confident about your ability to handle your personal problems? (*)
5. In the last month, how often have you felt that things were going your way? (*)
6. In the last month, how often have you found that you could not cope with all the things that you had to do?
7. In the last month, how often have you been able to control irritations in your life? (*)
8. In the last month, how often have you felt that you were on top of things? (*)
9. In the last month, how often have you been angered because of things that were outside of your control?
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

Appendix D – Schedule of Push Notifications

Table 2

Timing and content of notifications in the study period

Timepoint	Notification
After assigning participants to study	Welcome! Further information will follow tomorrow! :)
Day 1:	
8 AM	Thank you for your patience; New information are available!
7 PM (if not completed yet)	Have you read all information? We'll start tomorrow morning :)
Day 2-7:	
8 AM	Good morning :) Tell me how you are feeling!
12 PM	Lunch time :) Tell me how you are feeling!
7 PM	Tell me how you are feeling! And enjoy your evening :)
9:30 AM, 1:30 PM, 8:30 PM (if not completed yet)	Don't forget to tell me how you are feeling :)
To encourage	You are doing great! 4 more days to go! Good morning :) Only 2 more days. You're doing great! A few missed answers are no problem! Keep doing!
Day 8:	
9 PM	You've made a great job this week! :) Tomorrow you'll receive the ending questionnaires.
Day 9:	
8 AM	Today is your last day! Please fill in the 4 questionnaires
2 PM, 7 PM (if not completed yet)	Great job so far! Don't forget to fill in the last questionnaires! :)

Appendix E – Further Visualisations of the Results

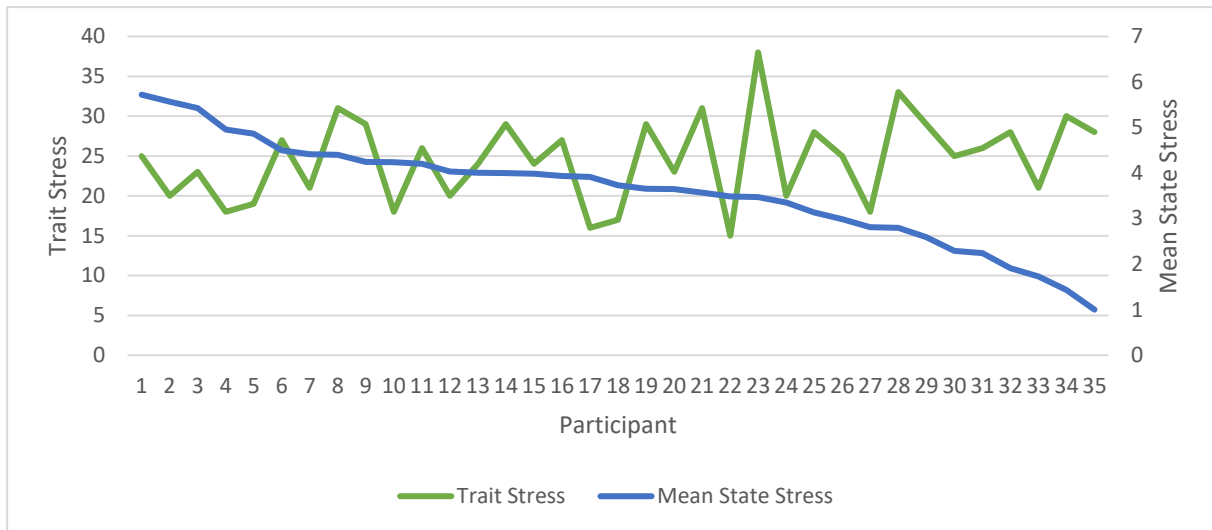


Figure 3. Line graph highlighting the association between trait stress and the estimated marginal means of state stress (PM) per participant, using a secondary axis for state stress.

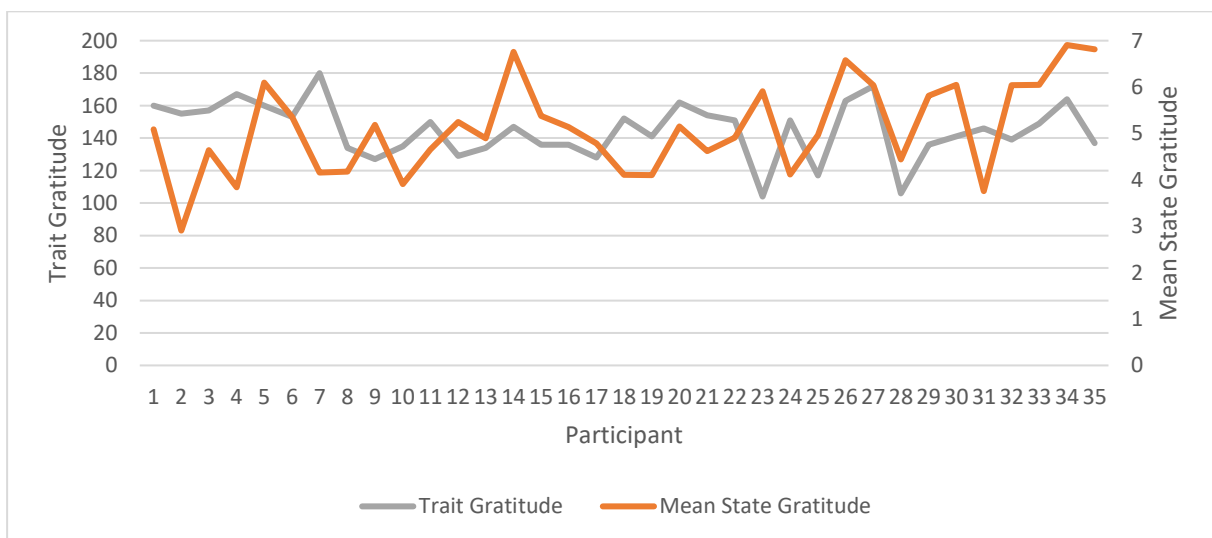


Figure 4. Line graph highlighting the association between trait gratitude and the estimated marginal means of state gratitude (PM), using a secondary axis for state gratitude.

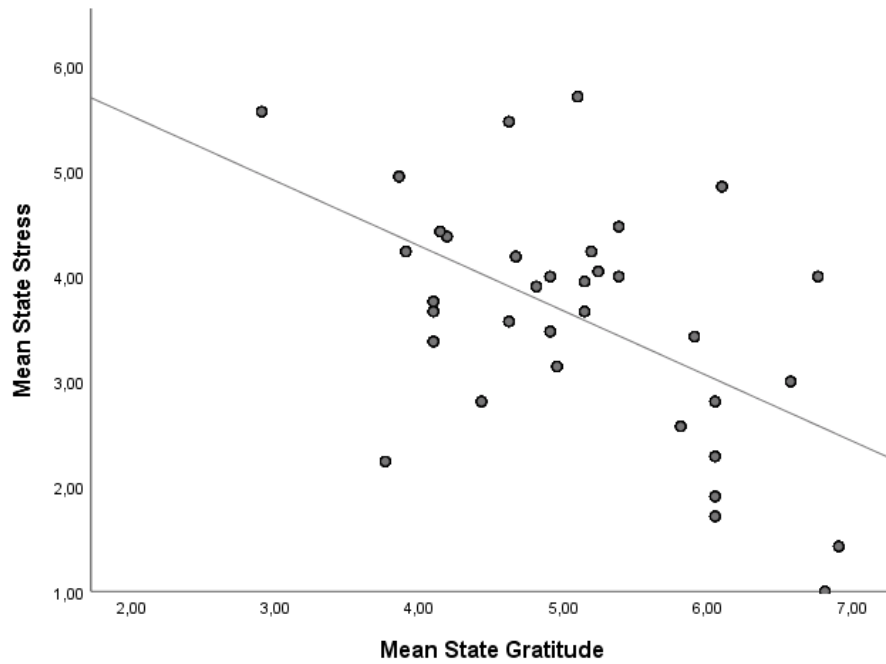


Figure 5. Scatterplot with fit line of state stress (PM) by state gratitude (PM) to illustrate the between-person association between stress and gratitude (as suggested by Curran & Bauer, 2011).

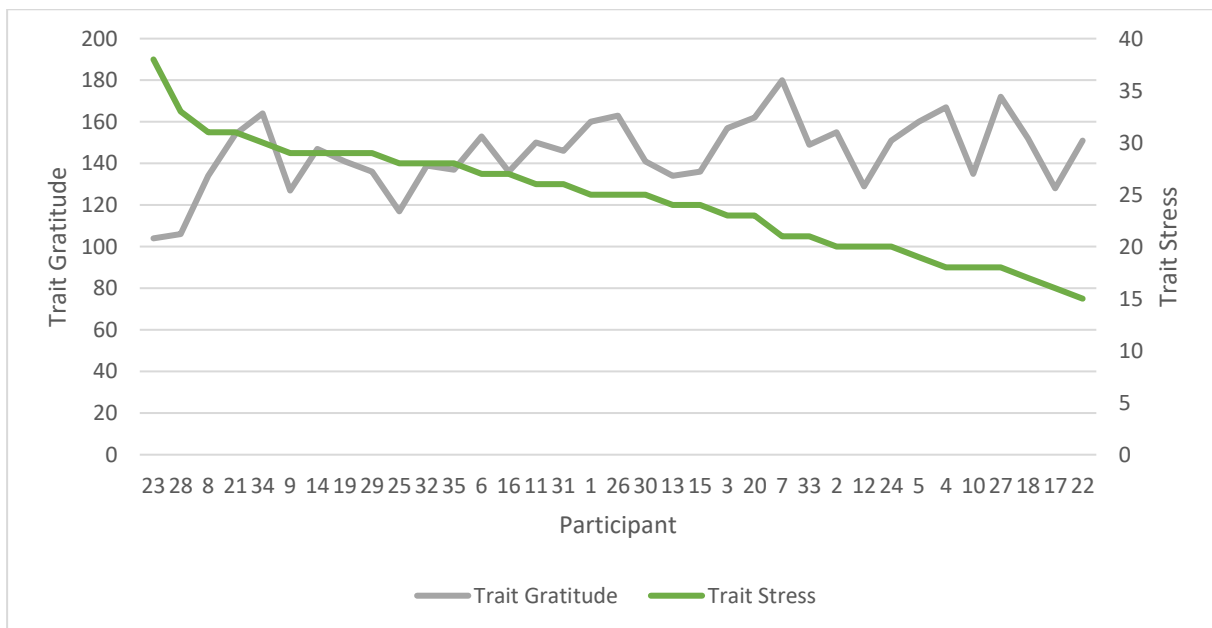


Figure 9. Line graph depicting the association between trait stress and trait gratitude for each participant, using a secondary axis for trait stress, and sorted by the highest level of trait stress descending to the right.