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The role of autonomy-connectedness in stress-modulating effects of social support in women: An experimental study using a virtual Trier Social Stress Test

L.E. Kunst [a,b,*], M.H.J. Bekker [a,c,d], J. Maas [a,e], M.A.L.M. van Assen [f,g], S. Duijndam [a], M.M. E. Riem [a,h,i]

[a] Department of Medical and Clinical Psychology, CoRPS - Center of Research on Psychological and Somatic disorders, Tilburg University, Tilburg, the Netherlands
[b] Mentaal Beter, Mental Health Center Region Noord-Brabant, Breda, the Netherlands
[c] Faculty of Behavioral and Movement Sciences, Faculty of Clinical, Neuro- and Developmental Psychology, VU University, Amsterdam, the Netherlands
[d] RINO Amsterdam, The Netherlands
[e] Center for Eating Disorders Helmond, Mental Health Center Region Oost-Brabant, Helmond, the Netherlands
[f] Department of Methodology and Statistics, Tilburg University, Tilburg, the Netherlands
[g] Department of Sociology, Utrecht University, Utrecht, the Netherlands
[h] Behavioural Science Institute, Radboud University, the Netherlands
[i] Clinical Child & Family Studies, Faculty of Behavioral and Movement Sciences, Vrije Universiteit, Amsterdam, The Netherlands

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ABSTRACT

Social support is associated with mental well-being and favorable therapy outcomes. As autonomy-connectedness, the capacity for self-governance in interpersonal context, may affect reliance on others, we investigated whether stress-modulating effects of social support are moderated by autonomy-connectedness. Ninety-seven undergraduates completed measures on autonomy-connectedness and trait social anxiety, and attended a laboratory session with a friend (support) or alone (control). All underwent a virtual Trier Social Stress Test and completed anxiety, cortisol and heart rate (variability) measures. Preregistered analyses revealed that social support reduced anxiety reactivity and delayed heart rate variability decreases, but not heart rate. Contrary to hypotheses, autonomy-connectedness did not predict stress-reactivity or interact with condition. Exploratory analyses suggested effects of social support on cortisol reactivity and indicated that reported support quality varied by trait anxiety and self-awareness. Our findings underline the stress-modulating effects of social support and suggest that social support can benefit individuals with varying levels of autonomy-connectedness.

1. Introduction

The human need for social connection is central to many leading socio-psychological theories (Bowlby, 1969; Erikson, 1963; Maslow, 1968). Evolutionary theories stress that humans are biologically predisposed to seek and maintain strong social bonds, because seeking and receiving emotional and instrumental support successfully may have increased our chances for survival (Baumeister and Leary, 1995; Cacioppo and Patrick, 2008). Even today, individuals who experience their environment as supportive show decreased risks to develop anxiety, depression (Gariepy et al., 2016) or cardiac disease (Barth et al., 2010), and even live longer (Holt-Lunstad et al., 2010). Social support seems to buffer against the disadvantageous effects of life stressors and thereby diminishes self-reported and physiological stress (Cohen and Wills, 1985; Ditzen and Heinrichs, 2014).

Although some theorists emphasize the universality of our tendency to seek social support (Baumeister and Leary, 1995; Coan and Sbarra, 2015), others (e.g., Bowlby, 1969) suggest that individuals differ in the extent to which they turn to others when facing threat. Whereas some avoid depending on their social environment (Girme et al., 2015), other people readily turn to important others when in need (McClintock et al., 2014; Schulte et al., 2008; Starr and Davila, 2008). Both support seeking styles can be adaptive if individuals are able to mobilize the level of support they need. However, difficulties in seeking, eliciting and utilizing social support, or excessive reliance on others, can have important consequences for mental health when preferred levels of social support

* Corresponding author at: Tias Building, Department of Medical and Clinical Psychology, Tilburg University, Warandelaan 2, 5037 AB Tilburg, the Netherlands.
E-mail address: l.e.kunst@tilburguniversity.edu (L.E. Kunst).

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are not met. Not only is poor social support related to increased risk for anxiety and depression (Gariepy et al., 2016), it also predicts worse treatment outcomes for these disorders (Jakubovski and Bloch, 2016; Lindfors et al., 2014; Lutz et al., 2018; Rapee et al., 2015; Shrestha et al., 2015). Understanding individual differences in the ability to benefit from social support therefore seems highly relevant for the treatment of anxiety and depression.

Studying social support experimentally typically involves inviting participants to a laboratory session with an acquaintance (social support) or alone. These studies demonstrate that social support decreases self-reported, cardiac and endocrinological stress-reactivity (see Ditzen and Heinrichs, 2014; Frisch et al., 2015). However, to date, most laboratory-based studies on stress-modulating effects of social support have focused on contextual factors (e.g., type of social support offered; Uchino et al., 2011), and only a few have investigated person-centered predictors of profiting from social support (Cosley et al., 2010; Creaven and Hughes, 2012; Meuwly et al., 2012).

More insight into individual differences in profiting from social support could be achieved by examining the concept of autonomy-connectedness, a concept closely related to themes of interconnectedness and (in)dependence. Autonomy is often defined as the capacity for self-governance (Bekker and Van Assen, 2006; Hmel and Pincus, 2002). It entails being aware of one's wishes, needs and opinions, and the ability to express these in social situations and to act upon them (Bekker and Van Assen, 2006). Although many different operationalizations of autonomy exist, many concepts include a social component that reflects what was originally proposed to be the 'opposite' of autonomy, an excessive investment in relationships and dependency (e.g., Beck's concept of autonomy-sociotropy; Beck, 1983; Clark and Beck, 1991). Earlier concepts also equated healthy autonomy to detachment from others (Hirschfeld et al., 1977), but were as such inconsistently related to mental health (Hmel and Pincus, 2002). Bekker (1993) argued that older autonomy concepts may have been based on an interpretation of autonomy as independence, perhaps stemming from a traditionally masculine perspective. However, women may on average prefer inter- rather than independence (Tamres et al., 2002). Whereas such behaviors were traditionally labeled as 'dependent' and therefore maladaptive behavior, Bekker (1993) postulated that interdependent behaviors should be viewed as a gender-related, healthy form of autonomy in the context of relatedness.

Consequently, Bekker and Van Assen (2006) developed the more gender-sensitive concept of autonomy-connectedness, in which autonomy is defined as self-governance rather than detachment (Bekker and Van Assen, 2006). Autonomy-connectedness consists of three components: i) self-awareness, the awareness of one's wishes, needs and opinions, and the ability to express these in interpersonal interactions; ii) sensitivity to others, being aware and sensitive towards the wishes, needs and opinions of other people; and iii) capacity for managing new situations, the inclination to explore and to feel comfortable in novel situations (Bekker, 1993; Bekker and Van Assen, 2006).

Clinical as well as population-based studies show consistent relations between autonomy-connectedness and psychopathology. Internalizing symptoms (i.e., anxiety and depression) are negatively and typically moderately associated with self-awareness and capacity for managing new situations, and positively and moderately associated with sensitivity to others (Bekker and Croon, 2010; Bekker and van Assen, 2017; Maas et al., 2019; Rutten et al., 2016). A laboratory-based study by Kunst et al. (2019) additionally showed that individuals with low self-awareness were more vulnerable to experience anxiety following a social stressor. These patterns reflect a tendency to excessively focus on the wishes and needs of others, while being less aware of or having difficulties acting upon one's own wishes and needs. Notably, externalizing symptoms (i.e., antisocial symptoms) are *negatively* associated with sensitivity to others (Bekker and van Assen, 2017), supporting the idea that mental health problems may occur if people are either 'too dependent' or 'too detached'.

As autonomy-connectedness implies an intricate balance between dependence and independence, studying its associations with experiences of social support could offer novel insights into individual differences of social support utilization. People may profit optimally from social support when acting upon their social needs, communicating these assertively, and thereby eliciting high quality support (Don and Hammond, 2017; Rutten et al., 2016). Individuals with internalizing psychopathology, however, often feel unable to cope with daily life situations by themselves, tend to behave submissively and rely on others excessively (e.g., De Beurs et al., 2009; Hawke and Provencher, 2012; Russell et al., 2011). This behavioral pattern may correspond with low levels of self-awareness and capacity for managing new situations, and high levels of sensitivity to others. Although individuals with a 'dependent' autonomy-connectedness pattern might profit greatly from social support in short-term, in long-term excessive support-seeking has several pitfalls, including feelings of fear and helplessness when supportive others are unavailable (Schulte et al., 2008). Excessive support seeking has also been shown to elicit unsupportive responses from others when perceived as 'clingy', contributing to higher depressive symptoms (McClintock et al., 2014; Starr and Davila, 2008).

Inversely, people may profit from social support insufficiently if they are relatively insensitive to others' opinions and affective expressions (Guerra et al., 2019). Interestingly, although descriptions of autonomy and dependency suggest that individuals exist who may be detached from others and unlikely to profit from social support, evolutionary theories suggest that even these individuals would experience some benefit of social support (Baumeister and Leary, 1995; Coan and Sbarra, 2015). These inconsistent ideas raise the therapeutically relevant question whether individuals with varying levels of autonomy are (in) sensitive to the effects of social support, and for instance, to what extent therapists should strive to enhance social support seeking and utilization in highly detached individuals. However, experimental studies on experiences of social support in direct relation to autonomy are scarce, and none have used the concept of autonomy-connectedness to investigate these relationships.

The present study was an experimental examination of the role of autonomy-connectedness in stress-modulating effects of social support among young female adults. As a manipulation of social support, participants were invited to the experiment either with a friend (social support) or alone (control condition). Stress was induced using an innovative virtual version of the Trier social stress test (TSST), in which participants interact with two online avatars, requiring no confederates (Fallon et al., 2016). Its effects are similar to in vivo TSST procedures for self-reported anxiety and preparatory sympathetic arousal (Fallon et al., 2021).

In addition to examining the moderating role of autonomy-connectedness in the stress-modulating effects of social support, the present study also functions as an extension of previous laboratory-based research on autonomy-connectedness and stress-reactivity. Specifically, Kunst et al. (2019) only included self-reported measures, whereas these measures correlate weakly with psychophysiological measures of stress-reactivity (heart rate, heart rate variability, salivary cortisol levels; Hoehn-Saric and McLeod, 2000). Combining self-report and psychophysiological measures provides a more complete picture of individual differences in multi-modal stress-reactivity.

The following hypotheses were formulated:

H1a. Self-awareness is negatively related to increased stress in response to the TSST.

H1b. Sensitivity to others is positively related to increased stress in response to the TSST.

H1c. Capacity for managing new situations is negatively related to increased stress in response to the TSST.

H2a. The effects of social support (condition) on increased stress is negatively moderated by self-awareness (weaker for individuals with higher levels of self-awareness).

H2b. The effects of social support (condition) on increased stress is positively moderated by sensitivity to others (stronger for individuals with higher levels of sensitivity to others).

H2c. The effects of social support (condition) on increased stress is negatively moderated by capacity for managing new situations (weaker for individuals with higher levels of capacity for managing new situations).

Hypotheses 1a–1c and 2a–2c, and no other hypotheses, were preregistered at the Open Science Framework, https://osf.io/acx23.

2. Methods

2.1. Participants

Ninety-nine female undergraduates were recruited on campus. Two did not attend the laboratory session, providing a total sample of 97 (age $M = 20.03$, $SD = 1.91$), of whom 46 (47.4%) were in the social support condition. Participants were born in the Netherlands (54.6%), Germany (27.8%), another country in Northern or Western Europe (5.2%), Balkan/Mediterranean country (7.2%), Baltic state (2.1%) or other (3.1%). Exclusion criteria were drug or alcohol abuse, use of prescribed medication (except hormonal contraceptives), cardiovascular diseases, psychiatric or neurological conditions, current or past pregnancy and high blood pressure. Although sample size was based on data availability, an a priori power analysis using G*Power 3.1.9.4 for independent samples *t*-tests showed that a sample of 90 is sufficient to detect medium effect sizes (Cohen's $d = 0.6$), given $\alpha = 0.05$ and with 80% power. All participants signed for informed consent and received a monetary reward or course credit for participation. The study was approved by the Medical Ethics Committee Brabant (NL60593.028.17), the study protocol was preregistered in the Dutch Trial Registry (https://www.trialregister.nl/trial/6192), and the analyses were preregistered at the Open Science Framework, https://osf.io/acx23. Except for one corrected error (see Statistical analysis) there were no departures from our preregistered plans, but we did add additional exploratory analyses, which are all labeled exploratory throughout the text.

2.2. Procedure

Participants were first screened in a meeting prior to their session in the laboratory of behavioral physiology (GO-LAB, Tilburg University). One week before the lab session, the autonomy-connectedness scale and fear questionnaire (see Measures) were completed online. Participants were randomly assigned conditions. In the social support condition, participants brought a female friend of their choosing to the laboratory, whereas participants in the control condition came alone. If possible, lab sessions were planned in participants' luteal menstrual phase, all sessions took place in the afternoon, and participants were instructed not to consume alcohol or undertake strenuous sports activities 24 h prior to the lab session, not to smoke or drink coffee on the day of the session and not to eat within 1 h before the session. Upon arrival, participants received information and signed for informed consent. As the present study was part of a larger study on stress-reactivity, all participants were administered a placebo nasal spray double blind, which participants were informed could contain oxytocin (50% chance; Riem et al., 2020). Participants then completed a short questionnaire to check adherence to the instructions for the lab session (e.g., no coffee and alcohol use) and current menstrual phase, and carried out two tasks unrelated to the present study. Participants were then fitted with the physiological equipment and completed a baseline rest measurement of 5 min while looking at a picture depicting a nature scene.

The virtual TSST procedure is depicted in Fig. 1 and its protocol is enclosed in Appendix A. The task consisted of a preparation period, mock interview (speech) and math task, all 5 min in duration. Anxiety and salivary cortisol were measured before the TSST (T1), after the TSST (T2), and 30 min (T3) and 45 min (T4) after onset of the speech task. At T4, those in the social support condition also completed a questionnaire on self-reported received social support and negative social interactions with their friend during the TSST. Heart period (for outcome measures inter-beat intervals, IBI; and root mean square of successive differences, RMSSD) was measured during rest (Baseline), preparation for the TSST (Preparation), interview (Speech) and the math task (Math).

2.3. Virtual TSST and social support

Participants were informed that they would carry out a mock interview for an internship position and a math task before two professors through an online program. Participants were asked to imagine that they were applying for their dream internship position and instructed to convince the professors that they would be the ideal candidate. Participants received a note block which could be used in preparation of, but not during their presentation. The present virtual TSST was developed by Fallon et al. (2016) and uses the online program Second Life, which allows users to interact with others through avatars. It has been found to elicit self-reported as well as endocrinological stress reactivity (Fallon et al., 2016). Prerecorded messages can be played by the experimenter to simulate conversations of an audience with the participant, thereby only requiring one experimenter (Fallon et al., 2021).

In the social support condition, the friend helped the participant in preparation of the presentation and she was explicitly instructed to offer

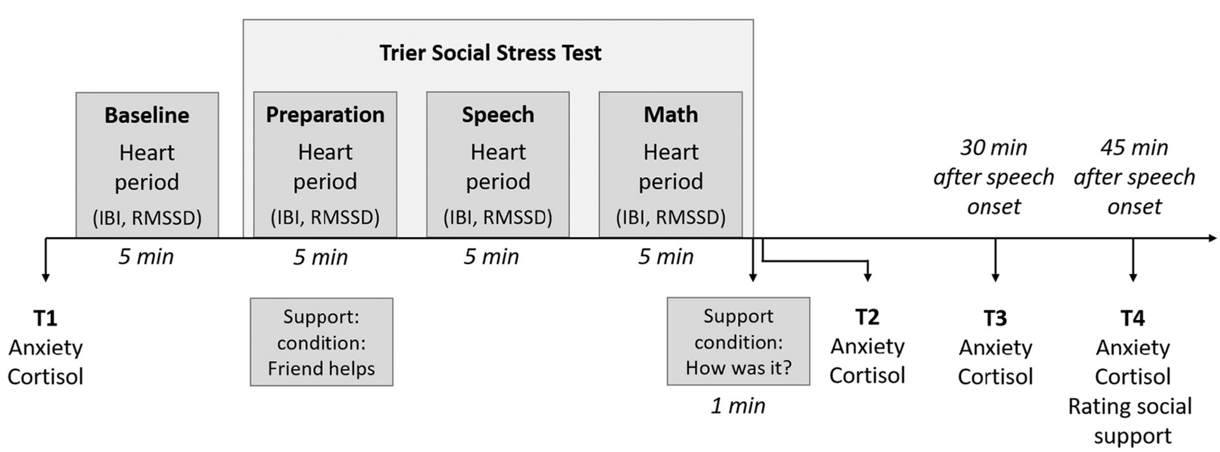


Fig. 1. Procedure of the Trier Social Stress Test and timing of outcome measurements.
Note: IBI = Inter-beat intervals; RMSSD = Root mean square of successive differences.

instrumental support (e.g., helping with the contents of the presentation) as well as emotional support (e.g., wishing her good luck). After the 5-minute preparation period, the friend was asked to leave the room and the experimenter showed the participant the Second Life environment. The experimenter subsequently operated the professors' avatars from the observer room, by clicking pre-recorded sound messages. During the 5-minute speech, the professor avatars made a bored/shrug gesture three times. If participants were silent for 3 s or longer, the professor avatars used probes to elicit more speech (e.g., 'can you tell us something about your weaknesses?').

After the presentation, the avatars gave instructions for the math task (5 min) in which participants subtracted 13 from a given number that differed each time (see Appendix A), and to subtract 13 again from the remainder. Each participant was told that their calculations were too slow and that they were making more mistakes compared with the other participants. Upon every mistake, the professor avatars responded with (variations of) 'that is incorrect, please start again from 1048'. After the math task, participants in the social support condition were allowed to talk with their friend for 1 min, after which T2 measures were completed. A recovery period followed, in which the friend left and the participant remained in the laboratory alone. The experimenter reentered the laboratory to complete T3 (30 min after Speech onset), T4 (45 min after Speech onset) and an elaborate debriefing.

2.4. Measures

Autonomy-connectedness was assessed using the autonomy-connectedness scale (ACS-30; Bekker and Van Assen, 2006). The ACS-30 has three subscales representing each of the components: i) Self-awareness (e.g., "If I am asked what I want, I mostly know the answer immediately"); ii) Sensitivity to others (e.g., "If I have things my own way against the will of others, I usually get very restless"); and iii) Capacity for managing new situations (e.g., "I need a lot of time to get accustomed to a new environment", inverted). Each statement is scored on a 5-point Likert scale ranging from 1 (disagree) to 5 (agree) and total scores are averaged. The ACS-30 has been shown to have good psychometric qualities (Bekker and Van Assen, 2006, 2008). In this study, reliabilities were 0.83 for self-awareness, 0.74 for sensitivity to others, and 0.76 for capacity for managing new situations.

State anxiety was measured using the Dutch abbreviated and state version of the Spielberger State-Trait Anxiety Inventory (STAI; Hedberg, 1972; Marteau and Bekker, 1992; Ploeg et al., 1980). The STAI distinguishes transient 'state' from stable 'trait' anxiety (Barnes et al., 2002) and has good psychometric properties (Ploeg et al., 1980). The abbreviated scale consists of 6 items (e.g., "I am tense") scored on a 4-point Likert scale ranging from 0 ("not at all") to 3 ("very much"). In this study, Cronbach's α for state anxiety varied between 0.73 (T4) and 0.82 (T2).

The *Fear Questionnaire* (FQ; Marks and Mathews, 1979) assessed 'trait' social and general anxiety and was included for descriptive purposes and as an additional covariate (see Statistical analysis). The FQ has adequate psychometric properties (Moylan and Oei, 1992) and asks respondents to indicate how often they avoid fifteen situations, on a scale from 0 (would not avoid) to 8 (would always avoid). The FQ has three subscales representing social anxiety (e.g., "being watched or stared at"), fear of blood/injury (e.g., "injections or minor surgery") and agoraphobia (e.g., "going into crowded shops"). The FQ also contains a section on negative emotions and impairment due to avoidance that were not used in the present study. Reliabilities were 0.66 for social anxiety and 0.83 for total anxiety. As preregistered, social anxiety was used as a covariate in the sensitivity analyses, whereas the social anxiety scale as well as the total anxiety score were used for exploratory analyses (see Statistical analysis).

Social support and negative interactions during the experiment were assessed using two subscales of the Dutch Social Support List (SSL; Bridges, 2002; Van Sonderen, 1990) and were only used for exploratory analyses, as preregistered. In line with dominant operationalizations of social support (Ditzen and Heinrichs, 2014), the original SSL inquires how often various types of social support occur ("Does it ever happen to you that people…"), including Emotional support (e.g., "…reassure you?") and Informative/instrumental support (e.g., "…provide you with help in practical everyday things, such as household chores?"). The list also contains 7 items on negative and unsupportive interactions (e.g., "…make disapproving remarks towards you?"). For the present study participants only completed the subscales on Emotional support (8 items) and Negative interactions (7 items), which were applied to the experimental context (e.g., "During the experiment, did your friend…", "…give you good advice?" [Emotional support], "…make unreasonable demands of you?" [Negative interactions]). Each item could be rated on a scale ranging from 1 (seldom or never) to 4 (very often). The measure can be seen as a subjective rating of received social support. Appendix A contains the utilized SSL and additional information about reported friendship quality.

The reliability of the Emotional support scale was 0.82. For the Negative interaction scale, 3 items contained no variation ('make disapproving remarks towards you?', 'blame you for things', 'treat you unjustly' were all answered 'seldom or never') and were therefore not included in the analyses. The remaining Negative interactions scale that consisted of 4 items and had poor reliability (0.61), which was driven by one item that could be interpreted as critical as well as supportive ('…react coolly'). We removed this item from the Negative interactions scale, resulting into a 3-item scale with a reliability of 0.85. Because the SSL was only used for explorative analyses, these decisions were not included in the preregistration. These explorative analyses were only run with this three-item Negative interactions scale.

2.5. Materials

2.5.1. Electrocardiogram

Heart period and heart rate variability were derived from continuous ECG recordings using a Biopac MP150 system, ECG100C module (sampling frequency 2000 Hz) and three hydrogel ECG electrodes. Data were processed in Acqknowledge version 4.4. The software automatically detected all markers in the ECG, and all R-peak markers were visually checked and corrected manually when necessary. Averages for heart period (inter-beat intervals; IBI, presented in milliseconds), beats per minute (BPM) and root mean square of successive differences (RMSSD) were computed for each experimental period (baseline, preparation, speech, and math) and analyzed in BIOPAC's AcqKnowledge software package (version 4.4). IBI and BPM both represent heart rate, but IBI is commonly used in analyses instead of BPM, because this variable tends to approximate a normal distribution more than does BPM (an a-priori decision included in the preregistration; see Statistical analysis). RMSSD reflects heart rate variability, with higher levels indicating more cardiac parasympathetic activity (more 'rest'). Note that IBI and RMSSD were used for hypothesis testing, whereas BPM was included as a descriptive measure only, as preregistered. ECG data of 10 participants was incomplete due to data collection errors (five), artefacts (four) and software malfunction (one). As described in the preregistration, all available data were used and missing values were not imputed or replaced. For instance, if participant's Speech data was unusable, we used all other available data (e.g., Baseline, Preparation, Math). IBI and RMSSD were log-transformed for mixed models analysis, *t*-tests and correlations.

Salivary cortisol samples were collected at the same timepoints as state anxiety (T1 to T4), using cortisol salivettes (Sarstedt, Nümbrecht, Germany). Participants were instructed to chew on the white pad for 60 s, and samples were stored after each lab session at −20 °C. For analysis, samples were defrosted and centrifuged at 2000 G for 10 min, creating a clear supernatant of low viscosity. A duplicate analysis was performed using 100ul of saliva (standard procedure). Cortisol levels were determined using a competitive solid phase time-resolved fluorescence immunoassay with flouromeric end point detection (DELFIA). The mean intra-assay coefficient of variation was 4.3%. Cortisol data of 90 participants were obtained, due to the target sample size for cortisol of the larger study (Riem et al., 2020).

Cortisol responders were identified as descriptive statistics, using the criteria of a 1.5-nmol/l rise (Miller et al., 2013), whereas continuous cortisol levels were used for hypothesis testing. Cortisol was log-transformed for mixed models analysis, *t*-tests and correlations. In all cortisol analyses we excluded outliers as preregistered, defined as individuals whose cortisol score at baseline deviated with 3 or more standard deviations from the baseline sample mean.

2.6. Statistical analysis

Analysis plans were preregistered at the Open Science Framework (https://osf.io/acx23) and carried out and reported exactly as preregistered, except for one corrected error.[1] Additional analyses that were not preregistered are explicitly labeled exploratory. Utilized data and syntax files are available upon request and through the Data Archiving and Networked Services (DANS) Dataverse repository (https://doi.org/10.34894/RELVW9). Analyses were carried out in SPSS, version 26. All hypothesis tests were carried out using two-sided hypothesis testing and an alpha of 0.05. The type I error chance was inflated due to the presence of four outcome measures (alpha of 0.1855 instead of 0.05). However, as adjusting *p*-values would excessively inflate type II error chances given our small sample, we did not apply multiple testing corrections. Instead, as preregistered, we reported how a *p*-criterion of 0.05 as well as a Bonferroni corrected *p*-criterion of (0.05/4 outcomes =) 0.0125 would have affected our results.

First, means and zero-order correlations of variables under study were computed (Tables 1 and 2). Preliminary analyses were carried out to i) assess within-subject changes in the outcome variables following the TSST, and ii) test effects of social support on stress-reactivity. Preliminary analyses were performed using the SPSS linear mixed models procedure with an unstructured covariance matrix. Per outcome measure (anxiety, IBI, RMSSD, cortisol), we estimated several models with increasing complexity: (I) intercept only; (II) intercept and time dummies; (III) intercept, time dummies, and condition; and (IV) intercept, time dummies, condition and the interactions between the time dummies and condition. Condition was dummy coded as −1 (control) and 1 (social support). Time dummies were coded so that each dummy represented incremental change compared with the previous timepoint. Model fit was tested using the −2 log likelihood (−2LL) and its associated chi square statistic using the program PQRS, with the difference in number of parameters between nested models serving as degrees of freedom. A significant chi square statistic for the change in −2LL (Δ−2LL) indicates that the model fit has significantly increased compared with a previous nested model.

The first aim of the preliminary analyses, to assess within-subject changes in the outcome variables following the TSST, was addressed by testing the *t*-statistic of each time dummy in model (II) including the intercept and time dummies. A significant *t*-test of these time dummies indicated that change in an outcome variables was significantly different from zero compared with the previous timepoint. The second aim of the preliminary analyses was to test the effects of social support (condition) on stress-reactivity. This was done by testing the interaction terms between time and condition in model (IV), using the *t*-statistic. Significant condition*time dummy interactions after the baseline would indicate that social support had affected the development of outcome variables over time. If condition*time dummy interactions were found, simple effects analyses were carried out to assess at which time points the two conditions (social support vs control) differed with regards to the outcome variable. Effect sizes for changes in the outcome measures by condition were computed by creating change variables (see below), testing group differences in these change variables and computing Cohen's d_s (Lakens, 2013).

Confirmatory hypothesis tests were conducted using linear regression analyses, bootstrapped using 5000 samples, bias accelerated and corrected 95% confidence intervals and stratified by condition, to limit effects of influential cases. No multicollinearity problems were detected. The dependent variables were change in anxiety, IBI, RMSSD and cortisol from baseline to the timepoint at which stress was predicted to peak during the experiment. As preregistered, the outcome variable ‘anxiety change’ was computed by subtracting T1 (before TSST) anxiety scores from T2 (after TSST) anxiety scores. To compute the outcome variables ‘IBI change’ and ‘RMSSD change’, Baseline scores were subtracted from the scores during Speech. To compute the outcome variable ‘cortisol change’, T1 scores were subtracted from the T3 scores (30 min after Speech onset).

Subsequently, for every autonomy-connectedness component and for every outcome measure, a series of three linear regression models was estimated (3 components × 4 outcomes = 12 series, see Table 3). Model (I) included an autonomy-connectedness component (e.g., self-awareness) as independent variable and an outcome measure (e.g., anxiety) as dependent variable; in model (II) condition was added as independent variable; and in model (III) the interaction between an autonomy-connectedness component and condition was added as independent variable (e.g., self-awareness * condition). Incremental change in explained variance was assessed using the R^2 statistic and its associated *F*-test. Models I–III were run for the entire sample, including participants in the social support as well as the control condition. H1a through H1c were tested using the bootstrapped *p*-value of the test of each autonomy-connectedness parameter in model (I). H2a through H2c were tested using the bootstrapped *p*-value of the test of the interaction terms in model (III).

As preregistered sensitivity analyses, hypothesis tests H1a through

Table 1
Means and standard deviations of outcome measures by condition.

Social support					
	N	Before (T1)	After (T2)	30 min (T3)	45 min (T4)
Anxiety	46	11.22 (2.86)	14.76 (3.60)	10.46 (2.57)	9.26 (2.05)
Cortisol	45	4.50 (3.13)	4.68 (3.18)	4.02 (2.46)	3.49 (1.81)
	N[a]	Baseline	Preparation	Speech	Math
BPM	40–42	69.96 (9.96)	80.04 (11.27)	85.46 (13.77)	81.13 (14.31)
IBI	41–43	881.56 (169.35)	772.14 (166.65)	724.34 (150.20)	768.86 (168.96)
RMSSD	38–41	66.0001 (35.12)	54.11 (30.16)	45.15 (24.26)	49.92 (26.84)
Control					
	N	Before (T1)	After (T2)	30 min (T3)	45 min (T4)
Anxiety	51	10.61 (2.78)	16.14 (3.34)	11.04 (3.09)	9.86 (2.95)
Cortisol	43	3.73 (2.41)	5.30 (2.15)	3.38 (2.003)	3.29 (2.87)
	N	Baseline	Preparation	Speech	Math
BPM	49	70.30 (7.25)	83.05 (10.36)	85.72 (11.13)	80.26 (10.32)
IBI	49	861.71 (88.28)	732.67 (87.97)	710.63 (89.78)	757.63 (96.38)
RMSSD	49	66.01 (32.63)	47.70 (29.37)	48.13 (28.91)	53.99 (32.28)

[a] Depending on timing of artefacts and data collection errors, the number of participants analyzed differs per focus area.

[1] IBI, RMSSD and cortisol values were log transformed for the mixed model analyses, as these variables are typically skewed. In the original preregistered syntax file, however, the log transformations were erroneously also applied to the dependent ‘change variables’ in the regression analyses (https://osf.io/acx23, lines 362–368), which contained negative values and followed normal distributions. This error was corrected.

Table 2
Means, standard deviations and correlations between variables under study.

	Means				Correlations														
	Support		Control																
	M	*SD*	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Condition	–	–	–	–	–														
2. Age	20.17	2.03	19.90	1.81	0.07	–													
3. SA	3.36	0.83	3.31	0.84	0.028	**−0.24***	–												
4. SO	3.69	0.52	3.79	0.43	−0.103	0.025	**−0.26***	–											
5. CMNS	3.29	0.77	3.23	0.80	0.039	0.054	**0.36****	**−0.25***	–										
6. Social anxiety	2.39	1.37	2.20	1.20	0.073	−0.053	**−0.44****	**0.21***	**−0.45****	–									
7. Total anxiety	1.77	1.08	1.58	0.93	0.096	0.011	**−0.31****	0.13	**−0.37****	**0.87****	–								
8. Anxiety change	3.54	3.35	5.53	3.47	**−0.28****	−0.087	−0.13	0.094	−0.16	0.104	0.098	–							
9. IBI change	−157.59	99.38	−151.08	84.96	−0.036	0.074	0.15	0.15	−0.017	0.043	0.081	**−0.24***	–						
10. RMSSD change	−21.65	27.92	−17.88	26.57	−0.069	**0.25***	0.097	0.18	0.026	0.043	0.097	**−0.26***	**0.61****	–					
11. Cortisol change T3	−0.47	2.07	−0.36	1.29	−0.034	0.10	0.093	0.021	0.051	−0.098	−0.11	−0.009	−0.14	−0.013	–				
12. Cortisol change T2‡	0.18	1.83	1.57	1.20	**−0.41****	−0.079	0.026	−0.14	0.028	−0.11	−0.14	0.086	−0.18	**−0.23***	**0.54****	–			
13. SSL Emotional support	2.76	0.58	–	–	–	0.23	**−0.33***	0.14	0.011	**0.38****	**0.55****	−0.25	0.098	0.24	−0.14	−0.08	–		
14. SSL Negative interactions	1.08	0.28	–	–	–	0.079	−0.27	0.23	−0.070	0.040	0.20	−0.17	0.29	**0.37***	0.019	−0.14	0.15	–	
15. Luteal phase (*N*, %)	39	40.6%	45	46.9%	−0.079	0.058	−0.003	−0.053	−0.13	−0.01	0.032	**−0.29****	0.13	0.10	−0.061	0.020	0.10	0.12	–
16. Contraceptive free (*N*, %)	18	18.6%	16	16.5%	0.081	0.19	−0.16	−0.18	0.100	−0.050	0.065	−0.037	−0.19	−0.057	−0.027	0.14	**0.44****	0.037	0.016

* $p < .05$.
** $p < .01$.
‡ These correlations should be viewed as exploratory. SSL = Social Support List.

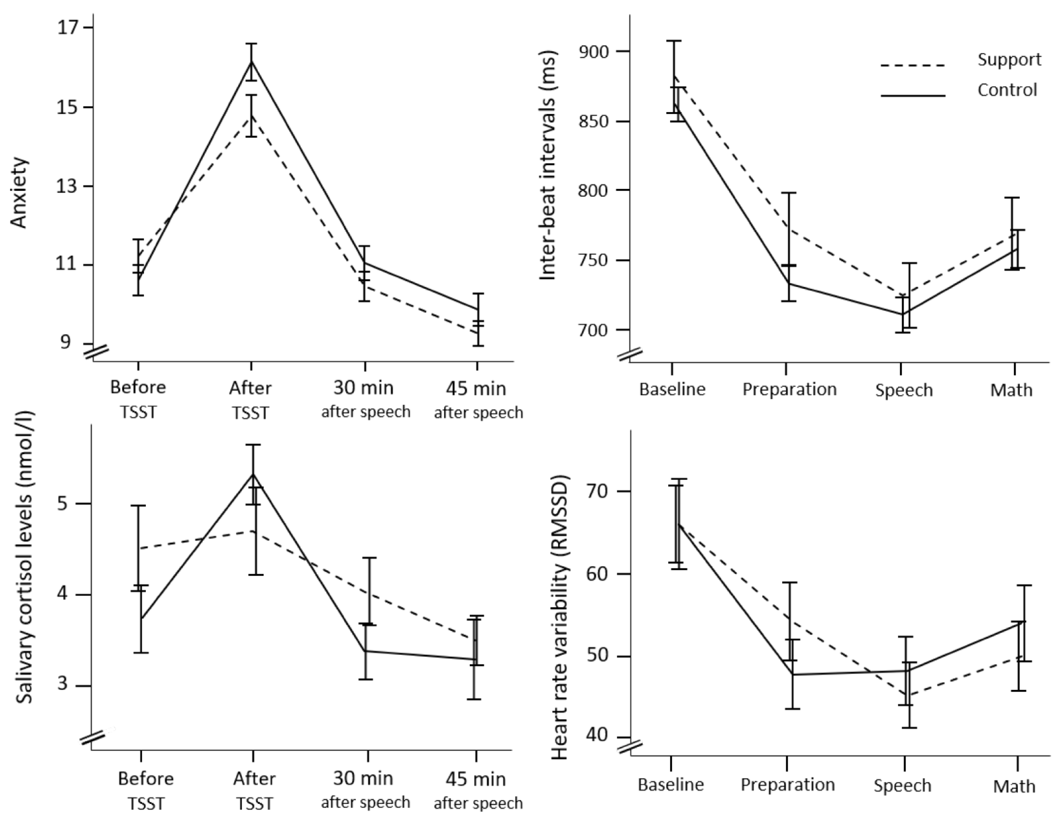
Table 3
Main and moderating effects of autonomy-connectedness on changes in anxiety, IBI, RMSSD and cortisol.

		Δ Anxiety			Δ IBI			Δ RMSSD			Δ Cortisol		
Self-awareness (SA)		B (SE)	*p*	ΔR^2	B (SE)	*p*	ΔR^2	B (SE)	*p*	ΔR^2	B (SE)	*p*	ΔR^2
I	SA	−0.56 (0.48)	.248	0.017	16.68 (12.37)	.182	0.023	3.14 (3.41)	.371	0.0094	0.18 (0.24)	.456	0.0076
II	SA	−0.52 (0.44)	.241	**0.077****	16.88 (12.44)	.178	0.0018	3.22 (3.49)	.368	0.0053	0.18 (0.24)	.443	0.0018
	Condition	**−0.98 (0.35)**	**.006**		−3.85 (9.79)	.701		−1.98 (2.95)	.511		−0.073 (0.18)	.691	
III	SA	−0.49 (0.43)	.259	0.013	17.63 (13.21)	.190	0.0032	3.40 (3.50)	.336	0.0014	0.18 (0.24)	.451	0.00070
	Condition	**−0.98 (0.35)**	**.006**		−4.08 (9.91)	.689		−2.01 (2.97)	.510		−0.073 (0.19)	.695	
	SA * condition	0.48 (0.42)	.252		6.27 (13.37)	.653		1.21 (3.56)	.732		−0.055 (0.24)	.824	
Sensitivity to others (SO)													
I	SO	0.70 (0.62)	.255	0.0089	31.25 (20.16)	.128	0.023	11.11 (6.76)	.110	0.034	0.046 (0.45)	.918	0.00015
II	SO	0.49 (0.59)	.404	**0.075****	30.82 (20.33)	.135	0.00030	10.72 (6.70)	.119	0.0018	0.025 (0.45)	.952	0.0014
	Condition	**−0.97 (0.35)**	**.006**		−1.60 (9.48)	.873		−1.16 (2.83)	.687		−0.065 (0.19)	.732	
III	SO	0.59 (0.62)	.332	0.0083	27.55 (19.71)	.160	0.0054	9.46 (6.59)	.156	0.013	0.12 (0.41)	.777	0.0059
	Condition	**−0.97 (0.35)**	**.006**		−2.26 (9.59)	.818		−1.36 (2.89)	.645		−0.053 (0.19)	.789	
	SO * condition	−0.69 (0.61)	.240		15.43 (20.08)	.433		6.98 (6.49)	.274		−0.30 (0.44)	.481	
Capacity for managing new situations (CMNS)													
I	CMNS	**−0.73 (0.36)**	**0.044**	0.026	−1.95 (10.55)	.860	0.00029	0.90 (3.16)	.775	0.00068	0.099 (0.30)	.751	0.0021
II	CMNS	−0.68 (0.36)	.057	**0.076****	−1.87 (10.84)	.865	0.0012	0.85 (3.21)	.783	0.0048	0.10 (0.30)	.746	0.0016
	Condition	**−0.97 (0.34)**	**.006**		−3.22 (9.95)	.758		−1.87 (2.92)	.533		−0.069 (0.19)	.727	
III	CMNS	−0.66 (0.38)	.073	0.0015	−3.10 (12.41)	.795	0.0064	0.23 (3.60)	.950	0.0077	0.075 (0.33)	.828	0.019
	Condition	**−0.97 (0.34)**	**.005**		−3.41 (10.07)	.744		−2.06 (2.98)	.499		−0.075 (0.19)	.702	
	CMNS * condition	0.18 (0.38)	.631		−9.25 (12.37)	.418		−3.09 (3.58)	.364		−0.30 (0.33)	.384	

Note: SE and *p*-values are based on bootstrapped 95% bias-corrected and accelerated confidence intervals (5000 samples). Cortisol analyses were controlled for menstrual phase and contraceptive use in a step prior to I (both $p > .05$ for all outcomes), and based on 4901 bootstrap samples.
** $p < .01$.

H2c were repeated using a fourth model (IV), in which control variables were added to model (III); the other autonomy-connectedness components, age, and the social anxiety subscale of the fear questionnaire. The aim of these sensitivity analyses was to examine whether the outcomes of hypothesis tests H1a through H2c would change when controlling for covariates. Furthermore, cortisol analyses were repeated with inclusion of outliers, and excluding participants who failed to adhere to instructions regarding alcohol, nicotine, coffee, sporting and eating, or who had wounds in their mouths. However, the analyses described prior to the sensitivity analyses determined our conclusions.

As exploratory analyses, we examined correlations between autonomy-connectedness components and subjective ratings of received



1

Fig. 2. Plotted mean scores (±1 SE) of anxiety, IBI, cortisol and RMSSD over time by condition.

social support. Following unexpected findings on cortisol reactivity, we also repeated the hypothesis tests H1a through H2c using a different cortisol change outcome variable, in which T2 scores (after TSST), instead of T3 (30 min after TSST onset), were subtracted from T1 (baseline).

2.7. Results

Descriptive statistics of variables under study are presented in Tables 1 and 2. There were no baseline differences between conditions in the four outcome variables, age, menstrual cycle, contraceptive use, social and trait anxiety, and autonomy-connectedness components, $ps > .05$. A total of 44.3% participants could be classified as cortisol responders; this percentage was 17.8% in the support condition and 72.1% in the control condition, X^2 (1) = 26.287, $p < .001$, large effect, $\phi(86) = 0.55$. Eighty-two participants (84.5%) were unfamiliar with Second Life, eight (8.2%) had heard of the program, six (6.2%) had seen it before and one participant (1.0%) had a personal account.

2.7.1. Preliminary analyses: effects of social support

Participants on average rated their friendship as positive (see Appendix A), evaluated their friend's behavior as supportive (Emotional support $M = 2.76$, $SD = 0.58$, on a 1–4 scale) and almost no unsupportive behaviors were reported (Negative interactions $M = 1.08$, $SD = 0.28$). As manipulation check, within-subject changes following the TSST were examined for the four primary outcome variables anxiety, IBI, RMSSD and cortisol (Fig. 2). For all outcome measures, each mean change from one timepoint to the subsequent timepoint was significantly different than zero, $ps < .001$ ($p = .045$ for RMSSD from T2 to T3, which would be non-significant when controlling for multiple testing). All models (II) including the time dummies improved in model fit compared with the (I) intercept only models: anxiety, $X^2(3) = 133.58$, $p < .001$; IBI, $X^2(3) = 127.076$, $p < .001$; RMSSD: $X^2(3) = 42.55$, $p < .001$; cortisol: $X^2(3) = 69.89$, $p < .001$. This suggests that the virtual TSST elicited within-subject changes in all outcome variables and across all timepoints.

As second preliminary analysis, we examined differences between conditions in the temporal development of the four outcome variables following the TSST (see Fig. 2). For anxiety, as expected, a significant interaction was found between time (T1 to T2) and condition, suggesting that individuals in the control condition became more anxious following the TSST than those in the social support condition, $B = -0.99$, $SE = 0.34$, t(97) = −2.89, $p = .005$, medium effect ($d = 0.58$). Simple slope analysis for anxiety at T2 revealed that the absolute level of anxiety right after the TSST (T2) did not differ between conditions, $B = -1.38$, $SE = 0.70$, $t(97) = -1.97$, $p = .051$. Changes in anxiety from T2 to T3 and T3 to T4 did not differ between conditions either. The fit of the model containing condition, and interactions between condition and the time dummies, did not improve compared with the model including only the intercept and time dummies, $X^2(4) = 8.991$, $p = .061$, suggesting that effects of condition did not contribute to explained variance in anxiety beyond effects of time.

For IBI, no differences between conditions were detected in temporal development, $ps > .05$, and the difference between conditions in overall IBI change from Baseline to Speech was close to zero, $d = 0.071$. The addition of condition, and interaction terms between condition and time dummies also did not contribute to model fit, $X^2(4) = 5.72$, $p = .221$. This suggests that participants had similar average heart rates during the experiment across conditions.

RMSSD analyses revealed that individuals in the social support condition became more stressed from Preparation to Speech than controls, as evidenced by a steeper RMSSD decrease (time × condition interaction), $B = -0.10$, $SE = 0.032$, $t(89.4) = -3.16$, $p = .002$, which indicates withdrawal of the parasympathetic nervous system. Addition of the condition and interaction terms between condition and the time dummies also improved model fit, $X^2(4) = 12.18$, $p = .016$, though not when controlling for multiple testing. Visual inspection of the temporal development of RMSSD (Fig. 2) suggests that participants in both conditions reached similar overall stress levels during Speech and Math, but that changes in heart rate variability had a delayed onset in the social support condition. Simple slope analysis indeed revealed no differences in absolute RMSSD level by condition during Speech, $B = -0.061$, $SE = 0.097$, $t(91) = -0.64$, $p = .524$. Changes in RMSSD from Baseline to Preparation and Speech to Math did not differ between conditions, and the difference between conditions in overall change in RMSSD (Baseline to Speech) was small, $d = 0.14$.

In terms of cortisol reactivity, individuals in the control condition had larger increases in cortisol levels from before (T1) to after the TSST (T2), time × condition interaction $B = -0.19$, $SE = 0.036$, $t(88) = -5.31$, $p < .001$, large effect ($d = 0.89$), and larger decreases in cortisol from T2 to T3, time × condition interaction $B = 0.19$, $SE = 0.032$, $t(88) = 5.95$, $p < .001$, $d = 0.84$, compared with the social support condition. Addition of condition and the interaction terms between condition and the time dummies improved model fit, $X^2(4) = 39.88$, $p < .001$. Although in the predicted direction, the timing of the cortisol peak seemed to have occurred at T2 rather than at the preregistered comparison point T3. The difference between conditions in overall cortisol change from T1 to T3 was close to zero, $d = 0.067$. Simple slope analyses revealed that salivary cortisol levels were higher for participants in the control than in the social support condition right after the TSST (T2), $B = -0.20$, $SE = 0.097$, $t(88) = -2.099$, $p = .039$. These differences were no longer present at T3, $B = 0.18$, $SE = 0.10$, $t(88) = 1.71$, $p = .090$.

2.7.2. Hypothesis tests: role of autonomy-connectedness

To test H1a through H1c, we examined main effects of the autonomy-connectedness components on change in the outcome variables for the sample as a whole (models I). Self-awareness and sensitivity to others did not predict changes in outcome variables in response to the TSST (Table 3). Capacity for managing situations negatively predicted anxiety changes, $B = -0.73$, $SE = 0.36$, $p = .044$, but its introduction to the model did not add to the explained variance ($\Delta R^2 = 0.026$, $F(1, 95) = 2.54$, $p = .115$) and its effects disappeared when controlling for condition (Table 3), other autonomy-connectedness components or social anxiety (see Sensitivity analyses and Multiple testing). To test H2a through H2c, the interaction terms between autonomy-connectedness components and condition were examined. Autonomy-connectedness components did not interact with social support, suggesting that effects of social support on stress reactivity were similar for individuals with varying levels of autonomy-connectedness (Table 3).

2.7.3. Sensitivity analyses

The preregistered sensitivity analyses included a repetition of the analyses in Table 3, with the addition of the other autonomy-connectedness components, age and social anxiety as covariates. Addition of these variables did not alter the results, except for eliminating the significant relation between capacity for managing new situations and anxiety change (Table 3, CMNS, step 1). A notable finding from the sensitivity analyses is that the covariate social anxiety did not predict changes in anxiety, IBI, RMSSD and cortisol in response to the TSST (also visible in correlations, Table 2).

Furthermore, also as preregistered, we repeated the main cortisol analyses without excluding participants with extreme cortisol values at baseline. Two participants had extreme values at baseline, which declined over the course of the experiment. As both participants were in the control group, including these participants eliminated main effects of condition on cortisol change. Excluding participants who did not adhere to the instructions for the laboratory session did not change the effects of condition on change in cortisol from T1 to T2.

2.7.4. Exploratory analyses

Associations between autonomy-connectedness and subjective ratings of received social support were examined exploratively. Self-awareness was negatively associated with self-reported received social support ($r(44) = -0.33$, $p = .023$, medium effect size). No associations were found between ratings of self-reported social support and the other autonomy-connectedness components (Table 2). Similarly, self-reported social support was positively associated with trait anxiety ($r(44) = 0.55$, $p < .001$, large effect) and social anxiety ($r(44) = 0.38$, $p = .009$, medium effect). In other words, participants with lower levels of self-awareness and higher levels of trait and social anxiety, indicated receiving more supportive behaviors, such as reassurance and 'nudges in the right direction'.

As cortisol levels peaked at T2 rather than T3, we repeated the main analyses using T2 as point of comparison as additional exploratory analysis. Consistent with the preliminary mixed models analyses, changes in cortisol from T1 to T2 were more pronounced in the control condition compared with the social support condition, $B = -0.72$, $SE = 0.17$, $p = .001$ (model II of the self-awareness analysis), but autonomy-connectedness components did not predict cortisol responses (model I) and did not interact with condition (model III).

2.7.5. Multiple testing

Adopting the more stringent Bonferroni p-criterion of 0.0125 would not change the within-subject effects of the TSST on the four outcome measures, except for changes in RMSSD from T2 to T3, which would become not significantly different from zero. The social support condition would still evidence less increase in anxiety from T1 to T2, a delayed RMSSD decrease and a less pronounced cortisol peak from T1 to T2. The proportion of explained variance in the mixed models analysis on the effects of condition on RMSSD would be non-significant. Main and moderating effects of autonomy-connectedness components would remain unchanged.

3. Discussion

The present study is an experimental examination of the effects of social support on multi-modal stress-reactivity, and the moderating role of autonomy-connectedness herein. In our sample of undergraduate women, social support decreased self-reported anxiety and delayed decreases in heart rate variability, whereas heart-period was unrelated to experimental condition. Autonomy-connectedness was not associated with changes in the outcome variables for the sample as a whole and did not interact with social support, suggesting that stress-modulating effects of social support were similar for individuals with varying levels of autonomy.

Our findings regarding social support parallel earlier experimental studies on its buffering effects on stress-reactivity (Ditzen and Heinrichs, 2014; Ditzen et al., 2008; Meuwly et al., 2012). Our multimodal assessment of stress allowed a fine-grained comparison of self-reported, cardiac and endocrinologic outcomes, and suggests that effects of social support may be most pronounced for outcome measures associated with threat perception (i.e., anxiety, heart rate variability and possibly cortisol; Allen et al., 2014; Frisch et al., 2015). Heart rate has also been found to increase in absence of social evaluative threat in studies using a 'friendly' TSST (Fallon et al., 2021) and may reflect motivational engagement and cognitive performance (Duschek et al., 2009). Interestingly, in our social support condition, heart rate variability showed a delayed response, suggesting that the parasympathetic system withdrew only after the social support had been terminated. This pattern corresponds with earlier laboratory studies in which social support was provided during the entire experiment, and in which more parasympathetic activity in social support conditions versus control conditions was shown throughout the study (Cosley et al., 2010; Kamarck et al., 1990).

Our findings furthermore suggest that autonomy-connectedness was unrelated to changes in the outcomes variables for the sample as a whole. The findings on anxiety contrast earlier results by Kunst et al. (2019), who found negative associations between self-awareness and anxiety increases following an impromptu speech task. A methodological explanation for this discrepancy is that our experimental study had sufficient statistical power (>0.8) to detect medium to large effects, but not small to medium effects. The effect sizes and corresponding statistical power may have been lower in our study than in Kunst et al. (2019), because we I) aggregated data of a control as well as support condition, II) used a virtual and potentially less stressful speech task, and III) assessed anxiety after the TSST instead of at peak stress (as in Kunst et al., 2019). In line with this reasoning, we found that trait social anxiety, a well-established predictor for experiencing anxiety under social evaluative threat (e.g., Crisan et al., 2016), also failed to predict anxiety and cortisol increases in our sample. Note that these arguments only pertain to anxiety and cortisol: As heart rate and its variability reached similar levels in both conditions and were measured throughout the study, it seems likely that autonomy-connectedness is not associated with stress-reactivity in these cardiac measures. Experimental studies with larger samples and including detailed anticipatory as well as recovery assessment are required to determine the consistency with which autonomy-connectedness predicts anxiety reactivity in a laboratory-based setting.

Furthermore, we tested whether stress-modulating effects of social support differed by autonomy-connectedness components. Contrary to our expectations, social support seemed to benefit participants regardless of their autonomy-connectedness levels. This finding seems in contrast with cross-sectional studies reporting associations between autonomy deficits and excessive reliance on others (McClintock et al., 2014; Schulte et al., 2008) and benefitting more from social support (Bakhshani, 2007; Cheung et al., 1997). An interpretation of these mixed results is that highly dependent individuals may engage in social support and assurance seeking more frequently in daily life than highly autonomous individuals, but when social support is offered in a laboratory setting non-optionally, both groups profit similarly. Although we should be careful not to accept null-hypotheses based on small sample sizes, our findings do seem in line with the proposed universal and biologically predisposed tendency to benefit from social support (Baumeister and Leary, 1995; Coan and Sbarra, 2015) and the tendency to 'tend and befriend' under threat (Taylor et al., 2000).

The finding that effects of social support on stress-reactivity did not depend on autonomy-connectedness levels could also be reflective of competing ideas about autonomy and profiting from social support. Whereas we expected autonomy deficits to relate to enhanced social support profiting, some authors have suggested that a healthy sense of autonomy may be essential for assertive communication of needs (Don and Hammond, 2017). When individuals lack such healthy autonomy patterns, they may have difficulties verbalizing their social support needs and experience burdensomeness when asking for help, complicating social support seeking and utilization. Similarly, studies on attachment styles have found impaired profiting from social support in individuals with anxious attachment styles (Meuwly et al., 2012; Stanton and Campbell, 2014). The association between autonomy-connectedness and profiting from social support may therefore depend on the presence other (autonomy-related) factors, such as assertive communication skills, attachment, the ability to verbalize needs and perceived burdensomeness.

Additionally, our exploratory analyses provided indications that individuals with varying levels of self-awareness and trait anxiety may have perceived and utilized social support in different ways. Whereas highly self-aware and low anxious individuals reported less supportive interactions, low self-aware and highly anxious individuals reported receiving a lot of support, reassurance and 'nudges in the right direction'. The latter group may have had a higher need for social support and due to this attentional focus experienced their friend's behavior as more supportive. Alternatively, low self-aware and highly anxious individuals may have expressed many uncertainties, doubts and fears during their interactions with friends, eliciting higher levels of encouragement and soothing in their friends. This pattern is consistent with longitudinal research showing dependent individuals to elicit more social support than more autonomous individuals (Shahar, 2008). However, these associations were not preregistered and should be treated as exploratory findings. In particular, the association between self-awareness and social support did not emerge when controlling for multiple testing and requires replication.

Similarly, variance in cortisol reactivity was large in this sample, probably because of differences in cortisol reactivity across conditions. The higher proportion of cortisol responders and increased cortisol peak in the control condition suggested that social support decreased cortisol reactivity in our experiment. However, the difference between conditions only emerged when comparing baseline values to the cortisol values directly after the TSST (T2), whereas cortisol levels typically reach peak concentration levels 10 to 30 min after stress offset (corresponding with T3 as preregistered; Foley and Kirschbaum, 2010). An interpretation of this discrepancy is that participants experienced the TSST instructions and preparation phase as the main stressor instead of the speech task, producing a cortisol peak at T2 (±25 min after TSST instructions). However, also taking into account that effects of social support on cortisol only emerged when excluding outliers (as preregistered), the findings on cortisol seem less robust and should be interpreted with caution.

Given the moderating role of social support in treatment of anxiety and depression (e.g. Lutz et al., 2018; Rapee et al., 2015) our findings on the role of autonomy-connectedness in social support utilization and perception are relevant for theoretical frameworks of therapies targeting social connectedness, such as interpersonal psychotherapy and autonomy enhancing treatment (Bekker et al., 2016; Klerman and Weissman, 1994). Our findings suggest that enhancing ways in which individuals profit from social support should not be restricted to certain patients based on existing autonomy patterns (e.g., excessive inclination to rely on others or detachment). When offered, social support also seems to benefit those high in self-awareness and capacity for managing new situations, and low in sensitivity to others. Our study also provides preliminary evidence that it may be worthwhile to tailor interventions according to the autonomy- and anxiety-related expressions and perceptions of social support eliciting when under threat.

The present study was subject to several limitations. Most importantly, our sample was a non-clinical, young, highly educated sample of women, limiting the generalizability of our findings. Some clinical populations may not profit from social support as much as our healthy sample, and individual differences herein (i.e., related to autonomy deficits) might be more pronounced in clinical groups. The female-only sample could also have limited the cortisol reactivity in our sample, as women on average show more blunted cortisol responses (Liu et al., 2017). Similarly, oral contraceptive use was permitted, possibly limiting cortisol reactivity. It is also important to consider sex differences in stress-reactivity. Whereas previous research on the 'tend-and-befriend' response emphasized stronger affiliative stress responses in females (Taylor et al., 2000), pro-social responses to acute stress have also been demonstrated in males (von Dawans et al., 2012). Our single-sex sample prevents us from drawing conclusions about social support utilization under acute stress in males. Investigating sex differences in stress-modulating effects of social support is recommended.

Second, our sample had low statistical power to detect small to medium effect sizes. Significant interactions between autonomy-connectedness and social support might be found in larger samples, but based on our study, it seems unlikely that these associations are moderate or large in size. Third, all participants received a placebo nasal spray that participants thought could contain oxytocin. Although we cannot rule out placebo effects, we expect the influences to be limited as participants were informed that oxytocin produces no noticeable effects and participants reported no subjective effects of the placebo nasal spray. Fourth, given the present focus on autonomy, it is relevant to note here that participants were not allowed to *choose* social support, precluding us from drawing conclusions about intrinsic needs for social support and active support seeking. It is also unclear how participants and friends behaved prior to the laboratory session (e.g., travelling together and perhaps discussing exciting or difficult topics). Although no baseline differences were found between the social support and control condition with respect to anxiety and psychophysiology, we cannot exclude the possibility that pre-laboratory mood differences could have occurred, affecting stress reactivity. Finally, as friends of participants were instructed to provide both instrumental and emotional support, we cannot disentangle which support components drove the differences between conditions (i.e., presentations in the support condition may have been of higher quality).

Taking into account the limitations of the present study, we highlight several strengths and clinical implications. This is the first study in young women to study autonomy-connectedness in relation to stress-modulating effects of social support. Whereas most social support studies focus on contextual factors affecting stress-modulating effects (Uchino et al., 2011), ours assessed individual differences in a laboratory-based setting. The study and its analyses were fully preregistered, and inclusion of self-report as well as cardiac and endocrinological measures enabled a fine-grained assessment of effects of social support on stress-reactivity. Our results are in line with the proposed universality of the human tendency to utilize social support (Baumeister and Leary, 1995; Coan and Sbarra, 2015) and the female 'tend and befriend' response under threat (Taylor et al., 2000), and suggest that social support, when offered, can benefit individuals with varying levels of autonomy-connectedness. Enhancing ways in which patients can profit from support from their social environment therefore seems relevant regardless of patients' autonomy.

Compliance with ethical standards

All respondents signed for informed consent and data collection was carried out in accordance with the 'General Data Protection Regulation' (GDPR). The study was approved by the Medical Ethics Committee Brabant (NL60593.028.17).

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Preregistration and data availability

The analyses of the present study were preregistered at the Open Science Framework, https://osf.io/acx23. Data and syntax files are available to any researcher wishing to use them for non-commercial purposes through the Data Archiving and Networked Services (DANS) Dataverse repository (https://doi.org/10.34894/RELVW9) and upon request from the corresponding author.

CRediT authorship contribution statement

The study was conceptualized and designed by M. M. E. Riem, M. H. J. Bekker, J. Maas, and L. E. Kunst. Material preparation and data collection were performed by L. E. Kunst, M. M. E. Riem and S. Duijndam. Preregistration and statistical analysis were performed by L. E. Kunst and M. A. L. M. van Assen. The first draft of the manuscript was written by L. E. Kunst and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpsycho.2021.10.013.

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