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The role of sex and gender role self-concept in stress reactivity: Evidence from the Trier Social Stress Test (TSST)

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ABSTRACT

Aim: To investigate biological sex and gender role self-concept in stress reactivity, utilizing the Trier Social Stress Test for Groups (TSST-G).

Method: A sample of 175 participants (56 % women, $M = 39.2$ years, $SD = 12.5$) underwent the TSST-G. Subjective and biological stress indicators (salivary cortisol sCort) and sex hormones (estradiol, testosterone) were assessed. Gender role self-concept (Bem Sex Role Inventory), in particular agency (stereotypically associated with masculinity), and biological sex were considered.

Results: Women reported higher subjective stress, whereas men had a steeper increase in sCort levels throughout the TSST-G. Results suggest lower subjective stress responses in more agentic people, independently of sex. Agency was not associated with sCort levels. Exploratory analyses revealed no interaction between agency and sex hormones.

Conclusion: Our study identified correlations between gender role self-concept and subjective stress in a large, non-student sample. The data confirm associations of biological sex with sCort response.

1. General introduction

Stress stimulates a network of brain regions, including the prefrontal cortex, the amygdala, and the hypothalamus, and prepares the individual to take immediate action. Stress leads to a cascade of hormones being released, the most prominent and well-established being the steroid cortisol as an outcome of hypothalamic-pituitary-adrenal (HPA) axis activation (Leistner and Menke, 2020). The psychological response to a stressor which is directly linked to the biological mechanisms taking place, is largely shaped by how an individual perceives the stressor, which depends on their perceived resources for coping (Lazarus and Folkman, 1987). Thereby, biological and psychological mechanisms interact in the stress response.

Primarily, the immediate stress response is adaptive in regulating internal physiological states. However, dysregulations in the stress system and long-term exposure to stress profoundly influence physical health and longevity, as evidenced by numerous studies (Cohen et al., 2015; Liu et al., 2017b; O' Connor et al., 2021).

Both, psychological and biological stress responses have been shown to differ between sexes. Studies on sex differences in the biological stress response have indicated higher levels of biological stress markers in men compared to women, particularly in experimentally induced stress situations (Liu et al., 2017a; Reschke-Hernández et al., 2017). However, despite these biological differences, the subjective and self-reported perception of a threat shows a reverse pattern. Generally, women tend to report higher levels of perceived stress in comparison to men (Matud, 2004; Otten et al., 2024). A discrepancy between verbal and biological stress responses was first formulated by Lazarus Schwerdtfeger and Kohlmann (2004a). Schwerdtfeger and Kohlmann (2004a) discussed clinical consequences of such a discrepancy focusing on negative outcomes on cardiovascular health.

In our research, we are interested in the role of the gender role self-

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concept that specifically pertains to how individuals perceive and describe themselves with culturally defined traits that are compatible with the traditional masculine gender stereotype (termed instrumental or agentic) or traits that are compatible with the traditional feminine gender stereotype (termed expressive or communal). Masculine traits associated with agency include being "strong", "dominant", or "assertive", while feminine traits reflecting communion include being "sensitive to the feelings of others", "warm", or "gentle" (Athenstaedt, 2003; Sieverding, 2005). These two dimensions of the gender role self-concept are usually assessed by (short forms of) the Bem Sex Role Inventory (BSRI, Bem, 1974) or the Personal Attributes Questionnaire (PAQ, Spence et al., 1974). One needs to keep in mind that agency and communion are independent dimensions and that individuals can be high or low on these traits. If an individual, regardless of biological sex, has high scores on agency and low scores on communion, the gender role self-concept can be called "masculine"; if someone is high in communal and low in agentic traits, it can be described as "feminine". Individuals with high scores on both dimensions have been called "androgynous" (Bem, 1974; Manigault et al., 2021). Other terms that have been used in research to address the self-description with communal and agentic traits are *gender-related personality traits* (Hankonen et al., 2014) or *gender-linked personality traits* (Fritz, 2000). Even the term *gender identity* has sometimes been used to describe this concept. However, this is misleading, as the term gender identity rather describes a person's inherent sense of being a man, a woman or a nonbinary person which may or may not correspond to a person's biological sex (APA, 2023).

Although stress, as an inherent part of the modern working society, is less obviously prone to be influenced by an individual's gender role self-concept, acknowledging stress or admitting to being affected by it can be perceived as a sign of weakness, which contradicts the traditional male gender stereotype. In line with this, a systematic review on masculinity and help-seeking for depression found that adherence to traditional masculine norms influences men experiencing depression in three key ways: it affects their symptoms and how they express them; shapes their attitudes toward seeking help, as well as their intentions and actual help-seeking behavior; and, finally, impacts how they manage their symptoms (Seidler et al., 2016). Qualitative studies also identified the perception of weakness associated with acknowledging mental health issues in men (Delenardo and Terrion, 2014; Silvestrini and Chen, 2023; Staiger et al., 2020).

Classical masculine characteristics, reflected in the agency dimension of the gender role self-concept, may inhibit certain health-promoting behaviors, such as seeking help or acknowledging health issues (Courtenay, 2000). We hypothesize that the opposing findings in subjective stress reports (higher in women) and biological stress reactions (higher in men) are partly explained by underlying gender role self-concepts. Although gender role self-concept and biological sex can be correlated, they are distinct, as has been highlighted above, and therefore have to be looked at separately.

Studies regarding associations between gender role self-concept and self-reported stress find significant effects for agency. For example, Lipińska-Grobelny (2008) reported negative associations between agency (assessed by the BSRI) and perception of the stressfulness of the workplace, in female participants only. Beyond that, studies looking at more stable stress-related outcomes emphasized positive associations between agency and self-reported general mental health (Matud et al., 2019; Rohmann and Bierhoff, 2013) and negative associations with self-reported internalized distress (Huselid and Cooper, 1994). Very few studies also report (partly inconsistent) associations primarily with communion (called femininity or expressivity in the respective studies) and symptoms of anxiety, or depression (Arcand et al., 2023; Arcand et al., 2020) and in one case, also associations with higher subjective tension and perceived task difficulty in a speech task (Evans and Steptoe, 2003).

However, the body of research on associations between biological stress parameters and gender role self-concept is limited to only a few studies. A stress-induction study applying a simulated job interview by Sieverding et al. (2005) reported positive associations between instrumentality (= agency, assessed by the PAQ) and blood pressure reactivity but negative associations between agency and subjective stress reactivity. This study also identified the relevance of the gender role self-concept independently from biological sex. Agency was an even more important predictor of blood pressure reactivity than biological sex. Expressiveness (= communion) did not explain subjective stress reactions or blood pressure reactivity. In a cross-sectional study among female participants an interaction effect between gender role self-concept and cortisol on burnout scores was observed, with higher cortisol levels associated with higher burnout scores in women with a higher masculine gender self-identification (= higher agency, assessed by the BSRI) (Kautzky et al., 2021). A study by Manigault et al. (2021) observed associations between cortisol and gender role self-concept categories (with the categories masculine, feminine, androgyne, and undifferentiated self-concept which are based on median splits of the agency and communion scales of the BSRI) using a well-established stress-inducing laboratory paradigm, the Trier Social Stress Test (TSST) (Kirschbaum et al., 1993). They focused on habituation between two consecutive exposures to the TSST. Manigault et al. (2021) did not find associations of gender-role self-concept with cortisol levels during the first exposure in comparison to the second. In the second TSST, the group of individuals with an androgynous gender role self-concept showed a lower cortisol stress reactivity than the group with a masculine gender role self-concept. Subjective stress was not assessed in this study and the impact of the dimensions of agency and communion on cortisol stress reactivity was not assessed independently. Related, using the same four categories, Juster et al. (2016a) explored the effects on allostatic load represented by an index of biomarkers (i.e. heart rate, cortisol, diastolic blood pressure). A sex-by-gender role self-concept interaction emerged, with the highest allostatic load levels in undifferentiated men. However, from a methodological point of view, using median splits and categories (e.g., androgyny) is controversial, as cut-offs are arbitrary and sample-dependent while discarding variance and reducing statistical power.

As a concurrent investigation of subjective and biological parameters is lacking, we aimed to simultaneously explore the differential roles of sex and gender role self-concept on subjective and biological (cortisol secretion) stress response markers. We extend the previous study by Sieverding et al. (2005) by investigating cortisol instead of blood pressure reactivity. Also, given the significant role of sex hormones such as testosterone, estradiol, and progesterone—which differ markedly between biological sexes and interact with the HPA axis in regulating stress responses (Oyola and Handa, 2017)—we aimed to explore how hormone levels (estradiol, testosterone) are related to the biological stress response (salivary cortisol sCort). Hormonal variations in females, influenced by factors such as menstrual cycles, hormonal contraceptives, pregnancy, or menopause, add further complexity to this relationship (Sims and Heather, 2018). Evidence from studies like Juster et al. (2016b) suggests that adjusting for sex hormones can attenuate or eliminate observed sex differences in cortisol responses, emphasizing their potential mediating role in stress regulation. We also sought to investigate the potential interaction between gender role self-concept and sex hormone levels (estradiol, testosterone) to determine whether observed sex differences in stress responses are direct effects of biological sex or proxies for other biological or psychological factors.

Specifically, the current study aimed to test the following preregistered hypotheses:

H1. : Higher agency is associated with a lower subjective stress response to standard laboratory stress. This effect of agency is hypothesized to hold even after controlling for biological sex.

H2. : Agency is expected to be associated with altered cortisol stress responses (sCort).

H3. : The higher an individual's agency score, the larger the difference between subjective and biological stress responses to standard laboratory stress.

For H2, we did not specify the direction of this association a-priori due to limited findings in this area.

Additionally, we focus on the agentic dimension of the gender role self-concept in all hypotheses. Prior research has identified the agentic and not the communal dimension of the gender role self-concept as relevant for subjective and biological stress reactions (Matud et al., 2019; Rohmann and Bierhoff, 2013; Sieverding et al., 2005). However, to draw a complete picture, we also examined the role of communion in subjective and biological stress responses in a more exploratory fashion. Further, we exploratively investigated the interplay between sex hormones (estradiol and testosterone), sex, and agency in the biological stress response (sCort).

2. Methods

Preregistration, code, data, and supplementary material is available on osf.io (https://osf.io/4jyqc/?view_only=5ff16797bbd14f9092b7a179a3900b44, https://osf.io/nvxeu/?view_only=aa9e2235c9054d7a83607bac476093a8, https://osf.io/r2d9k/?view_only=8887f22cca634d1ab9d6c4bc3c53c731). The research project was approved by the Ethics Committee of Heidelberg University, Faculty of Behavioural and Cultural Studies (AZ Siev 2022 1/2).

2.1. Participants

One hundred seventy-five participants (56 % women) participated in the Trier Social Stress Test for Groups (TSST-G). They were on average 39.2 years old ($SD = 12.5$). Originally, we aimed to recruit a sample of 200 participants. Due to the expiration of the project funding, recruitment had to be terminated before we achieved this number.

Men and women in our sample showed significant differences in gender role self-concept, with men reporting higher levels of agency ($t(172.87) = 2.68$, $p = .008$; $M = 4.76$, $SD = 0.65$) compared to women ($M = 4.45$, $SD = 0.85$), and women reporting higher levels of communion ($t(170.3) = -4.78$, $p < .001$; $M = 5.28$, $SD = 0.81$) than men ($M = 4.72$, $SD = 0.72$). A minority of women, ($n = 5$) used hormonal contraceptives. Nineteen women indicated being menopausal.

Most of the sample held a degree from higher education and worked full-time. Details are provided in Table 1. For details on the correlations between the main variables of interest, see Supp. Table S12.

2.2. Procedure and design

Participants were recruited via a local newspaper in Baden-Württemberg, Germany, university mailing lists, and flyers that were distributed in cafés and shops, via social media, and personally. Interested people were screened by telephone.

Inclusion criteria: Participants had to be at least 20 years old and working at least part-time. These criteria ensured a working population, enhancing the study's relevance to real-life stress contexts while retaining a broad age range.

Exclusion criteria: Those working night shifts during our study period, people with chronic and/or current psychological or physical illnesses, people who had undergone a dental procedure shortly before their participation, as well as pregnant and breastfeeding women, were excluded from participation.[2] People were asked for different kinds of hormone medication during the screening procedure (e.g. thyroid hormones, hormone treatment during menopause or in case of cancer, steroids such as estradiol, progesterone, and testosterone). People were included or excluded based on case-by-case decisions.

Assessments took place between June and December 2022. Participants eligible for inclusion were invited to the laboratory of the Core Facility for Neuroscience of Self-regulation (CNSR) of Heidelberg University. Participants were sent an online questionnaire before coming to the laboratory (baseline questionnaire). The questionnaire was administered via SoSci Survey (Leiner, 2019). Informed consent was obtained at the beginning of the questionnaire. In the laboratory, participants underwent the Trier Social Stress Test for Groups (TSST-G) (von Dawans et al., 2011). The TSST-G offers a cost-effective method for inducing stress simultaneously in multiple participants. The TSST is a validated procedure for inducing a stressful situation. It consists of a mock job interview and an arithmetic task in front of a jury of two (male, female;

Table 1
Sociodemographic characteristics of participants at baseline ($N = 175$).

Baseline Characteristics	Men		Women		Full sample	
	n	%	*n*	%	*n*	%
Sex						
Female					98	56.0
Male					77	44.0
Nationality						
German					163	93.1
Other[a]					12	6.9
Marital status						
Single	29	37.7	36	36.7	65	37.1
Married/partnered	43	55.8	52	53.1	95	54.3
Divorced/separated	4	5.2	8	8.2	12	6.9
Widowed	1	1.3	2	2.0	3	1.7
Cohabiting	50	64.9	53	53.1	102	58.3
Highest educational level						
Secondary education[b]	11	14.3	16	16.4	27	15.4
High school degree/some college	11	14.3	22	22.4	33	18.9
University or postgraduate degree	55	71.4	60	61.2	115	65.7
Employment						
Full-time	63	81.8	40	40.8	103	58.9
Half-time	10	13.0	51	52.0	61	34.9
Mini-Job	4	5.2	7	7.1	11	6.3
Monthly income						
< 800 €					9	5.1
801 - < 1250 €					11	6.3
1251 - < 1500 €					8	4.6
1501 - < 2000					19	10.9
2001 - < 3000					39	22.3
3001 - < 4000					17	9.7
4001 - < 5000					27	15.4
5001 - < 6000					24	13.7
> 6000 €					20	11.4
Variables of interest	Men		Women		Full Sample	
	M	SD	M	SD	M	SD
Agency	4.76	0.65	4.45	0.85	4.59	0.78
Communion	4.72	0.72	5.28	0.81	5.03	0.82
Subjective Stress at t1	2.86	0.87	3.13	0.82	3.01	0.85
Subjective Stress at t2	3.36	0.95	3.80	0.96	3.60	0.98
Subjective Stress at t3	3.32	0.95	3.96	1.21	3.68	1.14
Subjective Stress at t4	2.25	0.73	2.61	0.82	2.45	0.80
Cortisol (log) at t1	1.35	0.53	1.20	0.39	1.27	0.46
Cortisol (log) at t2	1.46	0.61	1.08	0.46	1.25	0.56
Cortisol (log) at t3	1.84	0.69	1.38	0.55	1.58	0.66
Cortisol (log) at t4	2.15	0.63	1.73	0.59	1.92	0.64
Cortisol (log) at t5	1.79	0.63	1.44	0.57	1.60	0.62
AUC_i	244	241	110	182	169	221
AUC_g	604	348	410	219	496	300

Note. Participants were on average 39.2 years old ($SD = 12.5$).
[a] other nationalities were: Albanian ($n = 1$), Bulgarian ($n = 1$), French ($n = 1$), Dutch ($n = 1$), Austrian ($n = 2$), Russian ($n = 2$), Turkish ($n = 2$), Ukrainian ($n = 1$), American ($n = 1$).
[b] Lower or intermediate secondary school leaving certificate (Germany, secondary education ending after 9 or 10 years of education); male participants: no one with lower secondary school leaving certificate.

[2] In our sample, 12 individuals (7 women and 5 men) reported working in shifts. As they were specifically asked about their shift work status and were informed that only night shifts were considered a relevant exclusion criterion, these individuals were retained in our main sample.

advanced student research assistants, and/or doctoral students). An equal gender composition of the jury was ensured throughout the whole study. The timeline of the TSST-G can be seen in Fig. 1. Saliva samples were taken at time points T1, T2, T3, T4, and T5. Subjective stress (via questionnaires on iPads, SoSci Survey) was assessed at T1, T2, T3, and T4. Before the T1 measurement, participants were welcomed to the laboratory, briefed on the task, and filled in a short questionnaire on current confounders for cortisol (food, drinks, and physical activity), allowing them time to acclimate to the environment. Saliva samples were taken before answering the questionnaires. At the end of the TSST-G, participants were debriefed and compensated with 50€ for their participation. Later, all participants were contacted again for participation in a following ecological momentary assessment study (not relevant to the present paper). Assessments were always scheduled in the afternoons due to the circadian rhythm of cortisol (3 pm at the earliest, 5 pm at the latest). The median group size was four. Groups consisted of men and women.

2.3. Measures

2.3.1. Sex

Sex was assessed by asking participants which sex they would ascribe themselves to: Male, female, or non-binary.

2.3.2. Gender role self-concept (baseline questionnaire)

Gender role self-concept was assessed using the 30-item German version of the Bem Sex Role Inventory (BSRI) (Troche and Rammsayer, 2011). The questionnaire measures the self-description with stereotypical traits that are socially desirable for men and women via two dimensions of the gender role self-concept, namely agency and communion. Participants indicated how much they agreed with self-description of agentic traits (e.g., "dominant" or "assertive") and communal traits (e.g., "eager to soothe hurt feelings" or "affectionate") on a 7-point Likert scale ranging from 1 "never" or "almost never" to 7 "always" or "almost always". Cronbach's α for both scales were good (for agency: $\alpha = 0.87$ 95 % CI [0.84; 0.90], for communion: $\alpha = 0.89$ 95 % CI [0.87; 0.91]).

2.3.3. Subjective stress

As recommended in the standard TSST protocol (Birkett, 2011), subjective stress in the TSST was assessed via the 10-item German State Version of the State-Trait Anxiety Inventory (Grimm, 2009) and measured four times during the TSST-G (see Fig. 1). Items were, e.g., "I am nervous" or "I am happy" (reverse coded), and answered on a 7-point Likert scale from 1 "not at all" to 7 "very much" (Cronbach's α for T1 = 0.85 95 % CI [0.81; 0.88], for T2 = 0.89 95 % CI [0.87; 0.91], for T3 = 0.91, 95 % CI [0.89; 0.93], for T4 = 0.87 95 % CI [0.84; 0.90]).

2.3.4. Hormone analysis

Saliva was collected by passive drooling using SaliCaps® (IBL, Hamburg, Germany) and used to quantify cortisol (five times during the TSST-G; see Fig. 1) as well as estradiol and testosterone (at T1 and T5).

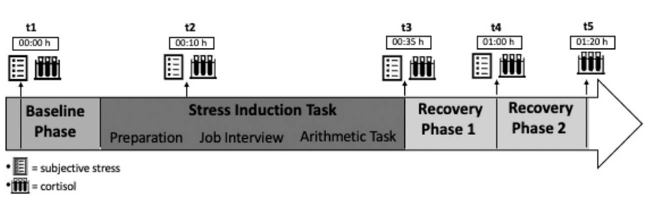

Fig. 1. Timeline of the TSST-G including the measures assessed at the time points.

Note. The Baseline Phase refers to the baseline measurement of the TSST-G and a short questionnaire to check for confounding aspects. A more extensive baseline questionnaire was administered at home. Subjective stress was measured via the STAI-State version. Cortisol was measured via saliva samples.

Cortisol (ng/mL) was quantified using a commercially available enzyme-linked immunosorbent assay from Demeditec Diagnostics GmbH (Kiel, Germany) following the manufacturer's protocol. Cortisol values were used to calculate the area under the curve with regard to increase (AUC_i) and the area under the curves with regard to ground (AUC_g) according to the formulas by Pruessner et al. (2003). AUC_i emphasizes changes in cortisol over time relative to the first value while AUC_g calculates the total area under the curve of all measurements. For cortisol data, AUC_g is indicative of the total cortisol output across all measurements while the AUC_i indicates the reactivity of the HPA axis in response to the stressor. It is recommended to use both measures since both represent different aspects of HPA axis functioning in response to a stressor (Pruessner et al., 2003).

Saliva samples were stored in a freezer at −80 degrees for no more than 6 months and were analyzed in the stress biomarkers lab at the Institute of Medical Psychology, Heidelberg. The intra-assay coefficient of variation (CV) for the sCort data was 2.54 % while the inter-assay CV was 4.59 %. Testosterone and estradiol levels were quantified by luminescence immunoassays (IBL, Hamburg, Germany). For the testosterone data, the intra-assay CV was at 3.2 %, and the inter-assay CV was 4.5 %. For the estradiol data, the intra-assay CV was at 4.1 % and the inter-assay CV at 6.6 %. Ten percent of all samples were analyzed in duplicates for each parameter.

2.3.5. Control variables and sociodemographic information

Age (in years), education (no formal education, basic secondary education, intermediate secondary education, high school diploma, university degree), working hours (in hours per week), partnership (single, married/partnered, separated/divorced/separated, widowed), living situation (with whom are you living together: no, partner, child/children, other relative(s), other flatmates; multiple answers possible) and physical activity in minutes per week were assessed to control for potential confounding effects. As state of the art for cortisol measurements, we assessed cycle phase coded as luteal (yes, no) or follicular (yes, no) with calculations based on data by Bull et al. (2019), taking hormonal contraceptives (yes, no) and BMI (computed via height and weight) (Stoffel et al., 2021). We did not differentiate the cycle phase into more fine-grained phases of mid-luteal, perimenstrual, mid-follicular and periovulatory as recommended by Schmalenberger et al. (2021) due to the small sample size.

2.4. Statistical analysis

All analyses were conducted using R (Version 2023.12.1). The dataset can be found on the Open Science Framework (https://osf.io/r2d9k/?view_only=8887f72cca634d1ab9d6c4bc3c53c731). The nlme package (3.1–164) (Pinheiro et al., 2024) was used for linear multilevel models. In all models, measurements on level 1 (L1) were treated as nested in subjects on level 2 (L2). A random intercept was included on L2 in all models. Models were compared using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The detailed analysis plan was preregistered.

For H1, the dependent variable was subjective stress. We increased model complexity in a stepwise fashion by first entering only the main effects of sex, agency, and time (entered as a factor with the first measurement occasion as reference category; m1). Model two (m2) included an interaction between time and agency, and model three (m3) included an interaction between time and sex. Model four (m4) allowed interactions between time and agency as well as time and sex.

For H2, a similar method was administered. Here, our variable of interest was sCort (logarithmized before the analyses). The same predictors as in H1 are being considered. In addition, we controlled for age, cycle phase, BMI, and hormonal contraceptive use. In the simplest model (m1), no interactions were allowed. Model two (m2) included an interaction between time and sex. Model three (m3) additionally allowed the interaction between time and agency. In a separate set of analyses, we predicted AUC_i and AUC_g from sex and agency (as well as the covariates included in the previous model) in a multiple regression model.

For H3, we computed the AUC_i for subjective stress and stacked it together with the AUC_i for sCort into one variable. For each participant, an area under the curve with respect to increase of their subjective stress was calculated. This index represents the change in subjective stress over time from t0 to t3. We z-standardized this index as well as the AUC_i for sCort. A dichotomous variable type was added to the data indicating whether a given observation represents the individuals' subjective AUC_i (type = 0) or their sCort AUCi (type = 1), respectively. We then computed a multilevel model with the stacked AUC variable as the outcome and type, agency, and the type x agency interaction as predictors.

Selected analyses for H1 and H2 were repeated with communion instead of agency (see supplement). Additionally, those analyses were repeated with the interaction between agency and communion (see supplement).

The exploratory analysis investigated the interaction between sex hormones (estradiol and testosterone measured at timepoint 1), sex, and gender role self-concept (agency and communion) in relation to (log-transformed) sCort levels using multilevel models. In each model, log-transformed sCort levels served as the outcome measure, with estradiol or testosterone (in separate models), sex, gender role self-concept (agency or communion, separate models), and their interactions as predictor variables. The control variables were the same as in the models examined for H2.

3. Results

3.1. Subjective stress

Change in subjective stress throughout the TSST-G separated by sex is displayed in Fig. 2.

Subjective stress differed significantly between the first and all following three measurement points with an increase from T1 to T2 by 0.59 scale points (95 % CI: 0.46; 0.72) and an increase of 0.66 scale points (95 % CI: 0.54; 0.79) from T1 to T3. Subjective stress at T4 (recovery phase) was lower by 0.56 scale points (95 % CI: 0.43; 0.69) compared to the measures at T1. Averaged across all measurement occasions, subjective stress was 0.30 scale points (95 % CI: 0.08; 0.51) higher in female than male participants.

Model comparisons favored the simplest model m1 (i.e., the model includes only the main effects of time, sex, and agency; see Table 2). Specifically, BICs indicate that the simplest model (m1) has a better model fit compared to the more complex models (m2, m3, m4). AICs yield weak evidence for differences in model fit between the four

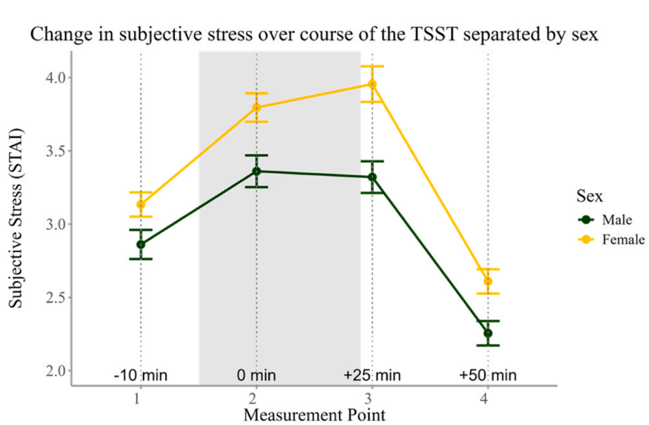

Fig. 2. Change in subjective stress throughout the TSST separated by sex. *Note.* Error bars indicate standard errors.

Table 2
Multilevel model for self-reported subjective stress (N = 175).

	Model 1					Model 2					Model 3					Model 4				
Effect	Estimate	SE	95 % CI LL	UL	*p*	Estimate	SE	95 % CI LL	UL	*p*	Estimate	SE	95 % CI LL	UL	*p*	Estimate	SE	95 % CI LL	UL	*p*
fixed effects																				
intercept	2.85	.089	2.67	3.02	< .001	2.85	.089	2.67	3.02	< .001	2.93	0.10	2.74	3.13	< .001	2.93	0.10	2.73	3.12	< .001
t2	0.59	.065	0.46	0.72	< .001	0.59	.065	0.46	0.72	< .001	0.50	0.10	0.31	0.69	< .001	0.52	0.10	0.33	0.71	< .001
t3	0.66	.065	0.54	0.79	< .001	0.66	.065	0.54	0.79	< .001	0.46	0.10	0.27	0.65	< .001	0.47	0.10	0.28	0.67	< .001
t4	−0.56	.065	−0.69	−0.43	< .001	−0.56	.065	−0.69	−0.43	< .001	−0.61	0.10	−0.80	−0.42	< .001	−0.62	0.10	−0.81	−0.43	< .001
agency (centered)	−0.42	.069	−0.56	−0.29	< .001	−0.37	.086	−0.54	−0.21	< .001	−0.42	0.07	−0.56	−0.29	< .001	−0.39	0.09	−0.56	−0.22	< .001
female	0.30	.108	0.08	0.51	< .001	0.30	.108	0.08	0.51	.007	0.14	0.13	−0.12	0.41	.283	0.15	0.14	−0.11	0.42	.258
t2x agency						−0.12	.084	−0.28	0.05	.161						−0.10	0.08	−0.27	0.06	.234
t3x agency						−0.13	.084	−0.29	0.03	.126						−0.09	0.08	−0.25	0.08	.308
t4 x agency						.057	.084	−0.11	0.22	.499						0.07	0.08	−0.10	0.23	.414
t2 x female											0.16	0.13	−0.09	0.42	.215	0.13	0.13	−0.13	0.39	.322
t3 x female											0.36	0.13	0.11	0.62	.006	0.34	0.34	0.08	0.60	.012
t4 x female											0.08	0.13	−0.17	0.34	.530	0.07	0.10	−0.16	0.36	.438
randome Effects																				
within-person variance	0.37					0.36					0.36					0.39				
between-person variance	0.39					0.39					0.39					0.36				
AIC	1592.84					1591.79					1590.95					1590.95				
BIC	1629.25					1641.85					1654.67					1654.67				

Note. CI = confidence interval; LL = lower limit; UL = upper limit.

models. Controlling for agency, being female was associated with higher average subjective stress ratings, $b = 0.30$ 95 % CI [0.08; 0.51], $p < .001$. Controlling for sex, higher agency, $b = -0.42$ 95 % CI [−0.56; −0.29], $p < .001$, was associated with lower average subjective stress ratings. Contrary to Hypothesis 1, there was no evidence that agency moderated the effect of the stress induction on subjective stress ratings since there was no time x agency interaction (p's > .126).

3.2. Cortisol (sCort)

Change in sCort throughout the TSST separated by sex is displayed in Fig. 3.

Model comparison (see online supplement Table S1) showed that the simplest model m1 (main effects only) and m2 (including the sex x time interaction) had comparable model fits, with the AIC favoring m2 and the BIC favoring m1. The most complex model m3 had the worst model fit indices. As the individual regression coefficients representing the interaction were all statistically significant, we chose m2 as the best-fitting model and report results from this model here (Table 3; results for the other two models are reported in the online supplement).

sCort levels at t1 were not statistically significantly different for male and female participants, $b = -0.01$, 95 % CI [−0.24; 0.23], $p = .858$. Controlling for sex, there was no statistically significant main effect of agency on sCort levels, $b = 0.00$, 95 % CI [−0.09; 0.09], $p = .982$. However, the increases in cortisol levels from T1 to the following four measurement occasions were all larger for male participants compared to female participants, all b's < −.21, all p's < .005.

In the multiple regression models (see Table 4), neither sex nor agency were statistically meaningful unique predictors of AUC_g (sex: $b = -0.24$, 95 % CI [−0.48; 0.01], $p = .058$, agency: $b = -0.03$, 95 % CI [−0.14; 0.07], $p = .490$)

Being female was associated with a statistically significantly lower AUC_i, $b = -102.63$, 95 % CI [−205.18; −0.09], $p = .050$. AUC_i was not statistically meaningfully related to agency, $b = 2.23$, 95 % CI [−41.82; 46.41], $p = .981$.

3.3. Contrasting subjective stress and cortisol increase

In a final set of preregistered models, we examined whether agency would predict the difference between the subjective stress response and the increase in sCort levels. There was no statistically significant type (self-report vs. cortisol) x agency interaction, $b = 0.16$, 95 % CI [−0.12; 0.44], $p = .261$, suggesting that agency was unrelated to the difference between subjective and biological responses to the TSST-G (see Table S5 in the supplement).

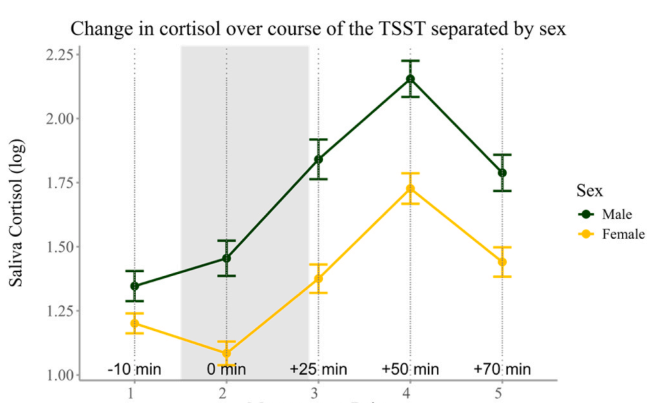

Fig. 3. Change in cortisol (log) throughout the TSST-G.
Note. Error bars indicate standard errors.

Table 3
Multilevel model for sCort ($N = 175$).

	Model 2				
Effect	Estimate	SE	95 % CI LL	UL	p
Fixed effects					
intercept	1.31	0.06	1.18	1.43	< .001
t2	0.12	0.05	0.02	0.23	.022
t3	0.52	0.05	0.41	0.62	< .001
t4	0.83	0.05	0.73	0.94	< .001
t5	0.46	0.05	0.36	0.57	< .001
female	−0.01	0.12	−0.24	0.23	.958
agency (centered)	−0.00	0.05	−0.09	0.09	.982
age (centered)	−0.01	0.00	−0.02	−0.01	.001
BMI (centered)	−0.02	0.01	−0.04	−0.01	.011
taking hormonal contraceptives	−0.05	0.16	−0.37	0.27	.760
being in luteal phase	−0.16	0.14	−0.44	0.11	.235
being in follicular phase	−0.14	0.11	−0.36	.09	.230
t2 x female	−0.23	0.07	−0.37	−0.09	.001
t3 x female	−0.33	0.07	−0.47	−0.19	< .001
t4 x female	−0.30	0.07	−0.44	−0.16	< .001
t5 x female	−0.21	0.07	−0.35	−0.07	.003
random effects					
within-person variance	0.10				
between-person variance	0.20				
AIC	1017.20				
BIC	1102.68				

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

3.4. Exploratory analyses

In our first set of exploratory models, we examined the role of the other dimension of gender role self-concept: communion. Re-running all models replacing agency by communion revealed no statistically significant effects of interactions involving communion (see tables S2, S3, and S4 in the supplementary document).

In a second set of exploratory models, we predicted (log-transformed) sCort by main effects and interactions among (a) estradiol (T1), sex, and agency; (b) estradiol (T1), sex, and communion; (c) testosterone (T1), sex, and agency; and (d) testosterone (T1), sex, and communion. In all these four models, time and the covariates included in the models used to test H2 were also included. The results of these four models are reported in Table S6 and S7 (supplement). There were no main effects or interactions involving testosterone on sCort, p's > .074. For estradiol, the only statistically meaningful effect was an interaction between communion and estradiol ($b = -0.03$, 95 % CI [-0.06 - −0.00], $p = .040$, see also Fig S1). This figure suggests that communion modulates the direction of the association between estradiol and total sCort output: For individuals with higher levels of communion, this association was negative, indicating less sCort output for individuals with higher estradiol levels. For individuals with lower levels of communion, this association was positive, indicating more sCort output for individuals with higher estradiol levels.

In further supplementary analyses, we included the interaction between agency and communion (see S8-S11) which did not yield any significant results.

4. Discussion

This study examined whether well-established sex differences and discrepancies between subjective and biological responses to stress exposure in a laboratory setting are related to variations in gender role self-concept. Specifically, a more masculine and agentic self-concept may conflict with one's self-perceptions and reports of stress, anxiety, or feelings of overwhelm. We predicted that an agentic self-concept would be associated with lower subjective stress reactions. As prior research (Sieverding et al., 2005) reported a positive association between agency and blood pressure reactivity, we investigated the

Table 4
Linear model for area under the curve with respect to ground or increase regressed on agency, sex, and control variables ($N = 170$).

	AUCg (log)					AUCi[a]				
	Estimate	SE	95 % CI			Estimate	*SE*	95 % CI		
			LL	UL				LL	UL	
Fixed effects										
intercept	6.23	0.06	6.11	6.35	< .001	246.45	25.18	196.72	296.17	< .001
agency (centered)	−0.04	0.05	−0.14	0.07	.490	2.23	22.34	−41.82	46.41	.981
female	−0.24	0.12	−0.48	0.01	.058	−102.63	51.93	−205.18	−0.09	.050
age (centered)	−0.01	0.00	−0.02	−0.00	.003	−3.84	1.58	−6.95	−0.72	.016
BMI (centered)	−0.02	0.01	−0.03	0.00	.082	−5.27	3.79	−12.75	2.22	.167
being in luteal phase	−0.13	0.15	−0.43	0.18	.409	−34.68	64.34	−161.74	92.38	.591
being in follicular phase	−0.11	0.13	−0.36	0.14	.394	−45.20	53.76	−151.36	60.96	.402
taking hormonal contraceptive	−0.09	0.18	−0.43	0.26	.616	−30.86	73.29	−175.58	113.87	.674

Note. CI = confidence interval; LL = lower limit; *UL* = upper limit.

association of agency with another biological stress response, cortisol reactivity.

Results suggest that on average, men reported lower subjective stress than women throughout all phases of the Trier Social Stress Test for Groups (TSST-G). In contrast to differences in subjective experiences of stress, men’s salivary cortisol (sCort) levels increased more strongly in response to the TSST-G compared to women’s sCort levels. With regard to gender role self-concept, agency was significantly associated with lower self-reported stress levels, explaining an independent part of subjective stress reactivity after controlling for sex. This confirmed our first hypothesis. However, our data provided no support for our second hypothesis that agency would be associated with sCort stress responses. With our third hypothesis, we wanted to shed light on the mechanism underlying the association between agency and self-reported stress. We did not find evidence that a potential dissociation between objective and subjective stress response is explained by agency, e.g., higher agency was not related to a larger difference between subjective and biological stress responses in our study.

Regarding sex differences in subjective stress and sCort, our findings are in line with previous research. For example, Kelly et al. (2008) report more negative emotions and mood states in women following the TSST than in men, and Helbig and Backhaus (2017) report higher subjective stress ratings of women in comparison to men in reaction to an oral academic presentation. sCort was used as an outcome measure in the TSST before and yielded the same sex differences as in our sample (Reschke-Hernández et al., 2017). These findings emphasize the importance of considering, assessing, characterizing, and communicating biological sex in stress research (Rich-Edwards and Maney, 2023).

More agentic men and women reported lower stress than less agentic men and women. This result is in line with previous limited evidence of gender role self-concept being relevant in health-related fields independent of biological sex (Sieverding et al., 2005; Willerth et al., 2020). The findings can be interpreted in two ways: that highly agentic individuals either experienced less stress or underreported their stress. Especially in fields where (sex) differences in stress are investigated, e.g. in representative population surveys, the consistent finding of the relationship between agency and lower self-reported stress should be considered in the interpretation of study results. Meta-analytic results indicate that men tend to be more agentic than women (Hsu et al., 2021). Following our reasoning, findings that men and more agentic people consistently *report* lower stress levels do not necessarily mean they actually *have* less stress.

One can argue that, on the one hand, reporting less stress is a positive feature, since in contrast, self-reported higher stress levels are associated with numerous adverse health outcomes, for example with cardiovascular disease (Steptoe and Kivimäki, 2012) and even mortality (Nielsen et al., 2008). On the other hand, repeatedly underreporting stress might lead to non-negligible negative health-related consequences, where for example offers of support come too late, support is not accepted or stress-reducing preventive behaviors are delayed.

Our findings differ from Sieverding et al. (2005) who found an association between agency and biological stress reactions (blood pressure). Contrary to previous analyses by Sieverding et al. (2005) who used blood pressure and heart rate as biological stress parameters, sCort was used in the present study to measure the biological stress response. One explanation might be, that cardiovascular and sCort measures reflect two different stress axes: the sympathetic nervous system as the immediate response to stress which increases heart rate and blood pressure, and the HPA axis as the system responsible for longer-term stress responses which causes the release of cortisol.

Additional mediating factors in the context of agency and cortisol might include ratings of controllability and processes such as cognitive reappraisal, problem-solving, or active coping measures, potentially reducing psychological stress perception and thus blunting cortisol responses (e.g., Liu et al., 2021).

It is also important to acknowledge the specific context in which the current results were obtained. In contrast to the original individual TSST, we used the group version (TSST-G), which introduces a more socially complex stress environment. Although the TSST-G is a validated and widely used paradigm for inducing psychosocial stress (von Dawans et al., 2011), it may engage different psychological mechanisms than the individual version. Factors like social comparison and perceived competition come into play in the group setting. Research suggests that men and women tend to respond differently to different stressor types: women show stronger responses to social rejection stress and men to achievement-related stress (Stroud et al., 2002). This might be particularly relevant for a group setting in which social evaluation and performance demands are combined. These sex-linked stress responses may also be shaped by a person’s gender role self-concept. Individuals high in agency may feel more competent and less threatened in performance-based social settings, while those high in communion may be more sensitive to interpersonal evaluation. Future studies should investigate whether the link between gender role self-concept and stress reactivity varies depending on whether the stress is induced individually or in a group context. Moreover, especially in a socially evaluative context, precarious manhood – viewing masculinity as an unstable social status that is easily lost – might amplify the stress response (Taylor, 2014). The composition of the group (e.g. other men only, other women only) modulates the stress response of men that perceive their masculinity as being threatened (Taylor, 2014).

More broadly, this highlights that stress responses are shaped not only by biological stress and gender role self-concept, but also the interaction between individual traits and expectations. Relating to this, self-perceived conflicts with the expectations of traditional gender roles (social and cultural expectations directed to men and women) could be an important avenue for gender-related stress research. The concept of gender role conflict (O’Neil, 2008) describes a state in which socialized gender roles result in cognitive, emotional, and behavioral problems that may cause stress, enhance existing stressors, or interfere with stress coping.

Our third hypothesis considered subjective and biological stress together. High correlations of subjective and biological (heart-rate) stress responses were previously found to be cross-sectionally related to well-being (Sommerfeldt et al., 2019), indicating that an alignment between the subjective and biological levels might be beneficial. However, comprehensive research on associations between subjective and biological stress shows associations between those concepts to be low in general across many studies (Campbell and Ehlert, 2012). Lupien et al. (2022) investigated the stress biomarkers in self-ascribed "very stressed out" and "zen" individuals and did not find differences in biomarkers between those individuals. As conclusion, they suggested difficulties in emotion regulation to be at the ground of differences in subjective stress. Differences in emotion regulation – although smaller than genuinely thought – exist between the sexes (Nolen-Hoeksema, 2012) but might interact with gender roles as has been shown in the literature on masculine norms and difficulties in displaying vulnerable emotions (Berke et al., 2018). Research on the association between emotion regulation and gender role self-concept is scarce and might be a fruitful avenue to detect underlying mechanisms between gender role self-concept and health-related outcomes.

Our exploratory analyses showed no clear significant associations between sex hormones and sCort. This is in line with research by Schoofs and Wolf (2011), who did not find associations between sCort and testosterone or estradiol concentrations in the TSST. Although not the main focus of our study, we also included communion in supplementary analyses (Tables S8-S11) and report models that include the interaction effect between agency and communion for subjective stress and cortisol responses. Our findings, that the inclusion of communion does not alter the conclusions of the preregistered models, relate to the weaker and inconsistent evidence regarding this dimension of the gender role self-concept for different stress responses (e.g., Arcand et al., 2023; Sieverding et al., 2005). However, we observed a weak interaction effect between estradiol and communion. While rather exploratory, these results could be a starting point for future research to tackle the interactive effects of factors involving biological sex differences (sex hormones) and psychological factors (gender role self-concept) for the regulation of the HPA axis.

4.1. Limitations

As a widely used and well-validated tool, we used the TSST-G to induce stress. Our analyses showed that it worked well in inducing stress in participants. However, the laboratory setting does yield limited ecologically valid results, given that its context considerably differs from real-world situations in which stressors occur. Thus, investigating associations between gender role self-concept and psychobiological stress during the everyday life routines of participants (e.g., using ecological momentary assessments; see Weber et al. 2022 for a recent overview) might be needed to make a more comprehensive conclusion regarding the overreaching hypotheses of the present work (i.e., regarding the association of gender role self-concept and biological stress reactions). We also need to acknowledge that the use of the TSST-G introduces a group dynamic that may interact with gender role self-concept in a different way than the individual TSST. The potential influence of the social context that is created by the group version of the TSST should be explored in future research.

While the STAI-State questionnaire we used specifically measures anxiety, it is widely used in TSST research as a proxy for psychological or subjective stress (Birkett, 2011). Nonetheless, we acknowledge that anxiety and stress are not conceptually identical, which may affect the interpretation of our findings regarding subjective stress.

Furthermore, because in the German language, the words for sex and gender are the same, asking our participants to self-identify their sex may have led to interpretations more aligned with gender. Therefore, we confirmed the correspondence between self-ascribed sex and biological sex by: 1) examining sex hormone levels and confirming higher testosterone levels in the male subsample, 2) checking for medication indicating sexual hormone treatment, and 3) personal contact with study participants. However, a more thorough assessment that allows the disentangling of gender and sex is advised for future studies.

As a further limitation, our results with regard to sex hormones have to be interpreted with caution. Due to the focus of our hypotheses on sCort, and given financial constraints, sex hormones could only be quantified for two of the five saliva samples provided by each participant. Thus, to extend and validate our findings, our results need to be replicated in future studies in which additional samples are quantified regarding the concentration of sex hormones.

Lastly, given the relatively small sample size, we were only able to consider the menstrual phase by broadly distinguishing between the follicular and luteal phases. We recognize that it would have been preferable to apply a more fine-grained method of the menstrual phases as, e.g., recommended by Schmalenberger et al. (2021).

5. Conclusion

Our study showed associations between gender role self-concept and subjective stress reactions in a large, non-student sample in Germany. While our data confirm the importance of biological sex to predict cortisol stress responses, gender role self-concepts, especially the agentic dimension, should also be taken into account when designing interventions for effective stress prevention and management.

CRediT authorship contribution statement

Schmidt Laura I.: Writing – review & editing, Validation, Methodology, Conceptualization. **Neubauer Andreas B.:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis. **Stoffel Martin:** Writing – review & editing, Validation, Methodology, Conceptualization. **Rafiee Yasaman:** Formal analysis. **Ditzen Beate:** Writing – review & editing, Validation, Supervision, Resources, Funding acquisition, Conceptualization. **Sieverding Monika:** Writing – review & editing, Validation, Supervision, Funding acquisition, Conceptualization. **Zintel Stephanie:** Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.psyneuen.2025.107480.

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