Mindfulness (2023) 14:1882–1892
https://doi.org/10.1007/s12671-023-02186-5

ORIGINAL PAPER

The Differential Effect of Oxytocin on Mindfulness in People with Different Resilience Level

Way Kwok-Wai Lau[1] · Dalinda I. Sanchez Vidaña[2,3] · Alan Pui-Lun Tai[4,5] · Jackie Ngai-Man Chan[2] · Lionel Ho-Man Ngan[2] · Mei-Kei Leung[6] · Benson Wui-Man Lau[2,3]

Accepted: 5 July 2023 / Published online: 22 July 2023

Abstract

Objectives Mindfulness skills have been shown to be an important attribute for mental and general well-being. The neurohormone oxytocin and resilience are established biological and psychological factors that are associated with mindfulness. This study aimed to elucidate the interaction of resilience and oxytocin levels as independent variables to predict mindfulness facets in university students.

Method Participants ($n = 96$) were university students in Hong Kong who previously participated in a resilience study with no history of mental health disorders or substance abuse. Mindfulness and resilience were measured using the Chinese versions of the Five Facet Mindfulness Questionnaire and the Connor-Davidson Resilience Scale, respectively. Saliva samples were collected to measure oxytocin levels using an enzyme-linked immunosorbent assay kit. A moderator analysis was conducted to assess the associations between oxytocin levels (predictor) and the five facets of mindfulness (outcomes) under the moderation effect of resilience (moderator).

Results The interaction between oxytocin and resilience levels predicted the *nonreactivity* facet of mindfulness. Specifically, oxytocin levels significantly and positively predicted *nonreactivity* in participants with low or moderate resilience levels, but not in those with high resilience.

Conclusion This study showed the influence of oxytocin levels on mindfulness was significant only in participants with low or moderate resilience, suggesting that oxytocin might act on other factors instead of influencing mindfulness in individuals with high levels of resilience.

Pre-registration This study is not pre-registered.

Keywords Mindfulness · Moderation · Oxytocin · Resilience

The risk of experiencing psychological problems is particularly high among adolescents (Kessler et al., 2007; Pedrelli et al., 2015). Epidemiological data reveal that about 75% of the cases of mental health disorders start between the ages of 17 and 24 years (Mohr et al., 2014). A recent meta-analysis of 192 epidemiological studies showed that the onset of mental health disorders coincides with the manifestation of dramatic biological changes in the brain caused by the transition from childhood to adolescence (Solmi et al., 2022). Furthermore, the onset of mental health disorders was reported to reach its highest point by mid to late adolescence (Solmi et al., 2022). A higher number of cases of mental

Way K-W Lau and Sanchez Vidaña contributed equally in this study.

✉ Way Kwok-Wai Lau
wkwlau@hkmu.edu.hk

[1] Department of Health Sciences, The Hong Kong Metropolitan University, Room F1229, 12/F, Hong Kong, China

[2] Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hong Kong, China

[3] Mental Health Research Centre, The Hong Kong Polytechnic University, Hong Kong, China

[4] Department of Special Education and Counselling, The Education University of Hong Kong, Hong Kong, China

[5] Bioanalytical Laboratory for Educational Sciences, The Education University of Hong Kong, Hong Kong, China

[6] Department of Counselling and Psychology, Hong Kong Shue Yan University, Hong Kong, China

health disorders have been reported in university students when compared to the general population (Auerbach et al., 2016; Levecque et al., 2017; Stallman, 2010).

University students go through both the challenging transition to university life and a critical biological developmental period (Duffy et al., 2019; Wang et al., 2020). Students have described the transition as a "loss experience" suggesting that they experience a loss of their previous identity, social connections, and sense of place while confronting the challenges related to finding a new identity (Cage et al., 2021). At the same time, the adolescent brain is going through a fast-developmental phase characterized by heightened sensitivity to exposure to risks that are commonly found in the university environment (Duffy et al., 2019). For instance, university students may experience psychosocial stressors, financial strains, sleep disruption, pressure from academics and peers to conform, and high expectations from family members to excel (Duffy et al., 2019; Mohr et al., 2014; Ratanasiripong et al., 2018). Facing those stressors continuously and persistently contributes to the exacerbation or onset of mental health disorders among university students (Pedrelli et al., 2015). To confront the challenging environment at this critical period in life, skills such as resilience and mindfulness play an important supportive role (Davydov et al., 2010; Leary & DeRosier, 2012; Ramasubramanian, 2017).

Resilience refers to a process to adapt and recover when facing adversity, trauma, tragedy, threats, significant sources of stress, or other challenging life experiences (American Psychological Association, 2022; Davydov et al., 2010), which has been recently conceptualized as the outcome of a dynamic process to successfully adapt to stressors (Kalisch et al., 2019; Lau, 2022). Although resilience was traditionally viewed as a unitary construct, it involves the dynamic combination of factors, including biological factors such as genotype, psychological factors such as emotion regulation and coping strategies, and social factors such as social support (Kalisch et al., 2019). In the context of coping strategies, cultivating mindfulness is a promising approach to enhancing resilience due to its association with the promotion of positive affect (Pidgeon & Keye, 2014).

Mindfulness concerns lucid awareness as a way to understanding what is occurring before conceptual or emotional classification takes place (Brown et al., 2007). Dispositional mindfulness is therefore understood as the awareness that emerges through paying attention, in the present moment, intentionally and non-judgmentally. It is an important resilience factor associated with well-being (Brown & Ryan, 2003; Calvete et al., 2019). Dispositional mindfulness is distinct from mindfulness state, where the former is a natural and inherent ability in all individuals to be mindful in their daily lives; it is stable over time and is independent from mindfulness training (Burzler & Tran, 2022; Medvedev et al., 2017). On the other hand, state mindfulness is the degree of mindfulness of an individual at any particular point in time, and it refers to the act of actively engaging in mindfulness in a specific moment (Brown et al., 2007; Medvedev et al., 2017; Tanay & Bernstein, 2013). Although dispositional mindfulness is different from state mindfulness, they are highly associated, in which people with higher dispositional mindfulness are believed to be more frequently engaged in a mindful state. One of the most popular tools to assess mindfulness is the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006), which measures mindfulness as an overall psychological construct having five dimensions, namely *acting with awareness*, *describing*, *nonjudging*, *nonreactivity*, and *observing* (Lecuona et al., 2021; Pelham et al., 2019). The FFMQ provides a summary of dispositional mindfulness and its specific components that provide measures of psychological well-being (Tang et al., 2019).

Higher levels of mindfulness have been associated with an increased use of adaptative coping strategies such as positive reappraisal and decreased use of maladaptive coping strategies such as rumination (Zhou et al., 2020). Increased awareness stimulates positive reappraisal of adversity leading to a better understanding of the situation, flexibility to reprioritize life areas, and the opportunity to build resilience as a response to facing negative events (Stefan & David, 2020). Research has shown that individual with "high mindfulness" and "non-judgmental" profiles of mindfulness reported less rumination when compared to individuals with "low mindfulness" and "judgmentally observing" profiles (Bravo et al., 2016, 2018).

Mindfulness training increases resilience, which leads to both positive emotion regulation (e.g., feeling calm and relaxed) and an increased ability to adapt in response to adversity (Ramasubramanian, 2017). The inclusion of mindfulness training has been recommended as a tool to reduce stress in university students and to improve resilience (Ramasubramanian, 2017). On the other hand, evidence shows that dispositional mindfulness can positively predict resilience in a large group of Japanese and Chinese university students (Yang & Oka, 2022). Another study conducted with university students found an association between mindfulness, resilience, and psychological well-being in which mindfulness and resilience predicted psychological well-being (Pidgeon & Keye, 2014). Therefore, exploring the levels of dispositional mindfulness and resilience in university students may indicate their ability to cope with adversity.

Given the beneficial effect of mindfulness on mental well-being, more recent studies tried to explore the underlying physiological mechanisms involved in mindfulness. One of the most commonly studied pathways is the oxytocin pathway. Oxytocin is a neuropeptide produced in the hypothalamus and secreted by the pituitary gland associated with the positive management

of emotions and well-being due to its buffering effect on stress, depression, and anxiety (La Fratta et al., 2021; Takayanagi & Onaka, 2022; Tang et al., 2019). The role of oxytocin in mindfulness has come to light in studies evaluating the biological changes that occur after practicing mindfulness. For instance, mindfulness practice has been associated with high levels of oxytocin which suggests a synergic mechanism that involves the oxytocin system to improve emotional regulation and increase well-being. In a study with university students, salivary levels of oxytocin were measured after a brief mindfulness session, and increased levels of oxytocin in saliva were detected when compared to the control group (Bellosta-Batalla, Blanco-Gandía, et al., 2020). In another study, a mindful-based intervention did not only increase the levels of oxytocin but also empathy (Bellosta-Batalla, del Carmen Blanco-Gandía, et al., 2020). Furthermore, a mindfulness-based mental training program induced changes in oxytocin release as detected in plasma (Hoehne et al., 2022). Because mindfulness training has been shown to trigger an increase in oxytocin levels, it has been suggested that salivary oxytocin could be used as a biomarker to assess the effect of mindfulness-based interventions (Bellosta-Batalla, Blanco-Gandía, et al., 2020). These findings suggest the plausible involvement of oxytocin in mindfulness-induced positive changes in mental well-being.

To date, evidence on the role of oxytocin in mindfulness has mainly emerged from studies evaluating changes in oxytocin levels after mindfulness-based interventions, but the role of oxytocin in dispositional mindfulness is still not fully explored. To the best of our knowledge, only two studies reported the association between dispositional mindfulness and salivary oxytocin levels. For instance, salivary oxytocin levels were reported to negatively correlate with *acting with awareness* in a mixed group of lesbians, bisexual, and heterosexual women (Dickenson et al., 2019). In a Master's thesis study, trait mindfulness was shown to negatively associate with salivary oxytocin levels during the recovery phase of a stress task at trend level (Bowlin, 2012). In contrast to the previous findings (Dickenson et al., 2019), dispositional mindfulness, as observed in the facet *acting with awareness*, has been associated with prosocial behavior and oxytocin is involved in social behavior processes (Churchland & Winkielman, 2012; Kil et al., 2021), which suggests a plausible positive association between dispositional mindfulness and oxytocin. For instance, people with higher level of awareness could be more aware of others' needs in the social environment, which could facilitate prosocial behavior (Condon, 2019; Donald et al., 2019).

Oxytocin has also been reported to be a biological factor of resilience. A previous study has shown that oxytocin predicts greater positive emotions, which is associated with better resilience during stress situations (Young Kuchenbecker et al., 2021). Oxytocin can be a key supporting player in resilience because of its role in the regulation of social behaviors (e.g., pair bonding, recognition, and social interaction) (Feldman, 2020; Sharma et al., 2020). The activation of the oxytocin system is known to attenuate the stress response in social affiliative situations and is associated to increased resilience (Takayanagi & Onaka, 2022), suggesting another pathway that oxytocin could contribute to mental well-being in addition to the positive influence on mindfulness.

Mindfulness is shown to positively influence resilience and mental well-being through mindfulness intervention studies. On the other hand, the effect of mindfulness interventions could be moderated by resilience state before training. For instance, the effect of meditation intervention on improving mental well-being was found to be significant only in people with low to moderate levels of resilience but not in those with high resilience levels (Barczak-Scarboro et al., 2021). These findings suggest the moderating role of resilience in the positive effect of mindfulness. The modulating effect of resilience on dispositional mindfulness has been ignored in the current literature. Although oxytocin appears to positively be associated with both mindfulness and resilience, it remains unclear whether the association between oxytocin and dispositional mindfulness could be different in people with different resilience levels. For example, oxytocin can affect social support (Ozbay et al., 2007), a resilience factor that is independent from dispositional mindfulness. Hence, oxytocin may contribute more to resilience factors other than mindfulness in people with high resilience, which weakens the association between oxytocin and dispositional mindfulness.

This study aimed to investigate the moderation effect of resilience on oxytocin in predicting mindfulness facets in university students. Firstly, the association between dispositional mindfulness and oxytocin was determined, and secondly the modulating effect of resilience on the relationship between dispositional mindfulness and oxytocin was investigated. We hypothesized that there is a positive association between oxytocin with dispositional mindfulness and that this association may be moderated by resilience.

Method

Participants

A total of 96 participants from several universities in Hong Kong were included. Participants were students above 18 years of age who had simultaneously joined a related study that focused on the investigation of psycho-biophysiological markers of resilience using a stress-induction task (Lau et al., 2021). Baseline data were used in this study, and the

resilience scores used in this study have been previously published (Lau et al., 2021). Participants were excluded if they had reported (1) a history of or currently suffering from any psychiatric or psychological disorders; (2) use of anti-inflammatory drugs; (3) pregnancy; (4) substance and/or alcohol abuse; and (5) with meditation background.

Procedure

The study was conducted in 2019 in Hong Kong before COVID-19. Power analysis for the statistic of multiple linear regression analysis with three independent variables (oxytocin levels, resilience scores, and their interaction term) was performed using the G*Power application to determine the sample size. The statistical power was set to 0.95 (β= 0.05), reliability of 95% (α= 0.05), and a moderate effect size of 0.15 (Pilot & Beck, 2006). The required sample size was 89. Participants were recruited through social media, poster advertisement, and an online platform using a snowball sampling method. On the experiment day, participants gave written consent and completed, in a quiet room, a set of questionnaires in Chinese to assess mindfulness and resilience. A separate questionnaire was used to collect the demographic information of the participants including age and gender. After completing the questionnaires, participants were guided by a researcher to provide a saliva sample (1 ml) using Salivette tubes (Starstedt, Nümbrecht, Germany). Participants were instructed to abstain from eating or drinking (except water) during the experiment and avoid consuming caffeinated products within 30 min prior to collection of the saliva sample. The saliva samples were centrifuged at 1000g for 2 min at 4°C, aliquoted, and stored at −80°C for further analysis.

Measurement of Oxytocin Levels in Saliva

Oxytocin levels in the saliva samples were measured using a commercially available enzyme-linked immunosorbent assay kit from Enzo Life Sciences (Farmingdale, NY, USA). Samples were processed in duplicate and analyzed according to the manufacturer's instructions. The detection range of the oxytocin kit was 15.60–1000pg/ml. The intra-plate and inter-plate coefficients of variation were 5.32 and 3.01, respectively.

Measures

Mindfulness was measured using the FFMQ (Baer et al., 2006). The Chinese version of FFMQ was adopted in this study (Hou et al., 2014). It consists of 39 items capturing five facets of mindfulness namely *observing* (8 items; attention and focus on selective stimuli), *describing* (8 items; express experiences to self and others), *acting with awareness* (8 items; the movements chose based on quick judgment, rather than automatically), *nonjudging* (8 items; self-acceptance and empathy), and *nonreactivity* (7 items; detachment from negative affects). The questionnaire is rated on a 5-point Likert scale, ranging from 1 (*never or very rarely true*) to 5 (*very often or always true*) (Baer et al., 2006). A total of 19 negatively worded items (3 items from *describing*; all items from *acting with awareness* and *nonjudging*) were reverse scored. A higher score represented closer relevance to each description of the sub-scale, and that someone is more mindful in their everyday life. In this study, the inter-item consistency (Cronbach's alpha) of the FFMQ ranged from 0.71 to 0.92, and the scale reliability (McDonald's omega) of the FFMQ ranged from 0.67 to 0.92. The Cronbach's alpha and McDonald's omega values are listed in Table 1.

Resilience was measured using the Chinese version of the Connor-Davidson Resilience Scale (CD-RISC) (Connor & Davidson, 2003; Xiaonan & Jianxin, 2007). This scale consists of 25 items rated on a 5-point Likert scale from 0 (*not true at all*) to 4 (*true nearly all the time*). The sum of scores were calculated from the 25 items, higher scores represent higher resilience. In this study, the inter-item consistency (Cronbach's alpha) of the CD-RISC was 0.89, and the scale reliability (McDonald's omega) of the CD-RISC was 0.89.

Data Analyses

Statistical analyses were conducted using the Statistical Package for Social Science (IBM SPSS v28). A $p < 0.05$ was considered statistically significant. No missing data were observed in this study. Normality of continuous data was examined using the Kolmogorov-Smirnov test. Salivary oxytocin levels were found to be non-normally distributed. Therefore, non-parametric methods such as Spearman's rho correlation and bootstrapping (5000 times) were adopted

Table 1 Demographic characteristics of the sample (n= 96), baseline scores, Cronbach's alpha and McDonald's omega values of the CD-RISC and FFMQ scales

Variables	Mean (*SD*) or frequency (%)	Cronbach's alpha	McDonald's omega
Age	21.17 (2.30)		
Gender (M:F)	49:47 (51:49)		
Oxytocin levels (pg/ml)	38.31 (11.11)		
CD-RISC scores	66.98 (11.25)	0.89	0.89
FFMQ-*Observing*	26.15 (5.79)	0.82	0.82
FFMQ-*Describing*	25.77 (5.39)	0.84	0.84
FFMQ-*Acting with awareness*	25.22 (6.74)	0.92	0.92
FFMQ-*Nonjudging*	20.16 (5.05)	0.81	0.81
FFMQ-*Nonreactivity*	21.73 (3.86)	0.71	0.67

CD-RISC Connor-Davidson Resilience Scale, *FFMQ* Five Facet Mindfulness Questionnaire, *SD* Standard deviation

in this study. The association of oxytocin levels with resilience and the five facets of mindfulness was analyzed using Spearman's rho correlation. To further investigate the association among oxytocin level, resilience, and the five facets of mindfulness, moderation analyses were performed using model 1 in the PROCESS macro v4.2 beta for SPSS (Hayes & Preacher, 2013). The association between oxytocin level (predictor) and the five facets of mindfulness (outcome variables) was tested under the moderation effect of resilience (moderator). The centered oxytocin level and resilience scores together with their interaction term were input into ordinary least squares regression models with 5000 bootstrap samples in predicting the five facets of mindfulness. Estimations of the independent variables (oxytocin levels and resilience) were performed for significant models to assess if the interaction of the independent variables predicts mindfulness facets. The significance of the interaction term is denoted by a significant increase in the *R*-squared (R^2) value due to the inclusion of the interaction term in the model.

Results

Ninety-six young adults (mean age = 21.17 years; standard deviation, *SD* = 2.30) participated in this study (Table 1). Forty-seven of them were female (49%). The mean oxytocin levels in saliva were 38.31pg/ml (*SD* = 11.11). The resilience as well as the scores in each facet of FFMQ are shown in Table 1. Mean scores in each facet of FFMQ in our samples were compared with the Chinese community data (Hou et al., 2014). Scores in the *observing* and *nonreactivity* facets were significantly higher in our samples ($p < 0.05$) compared with those in the community samples (mean age = 49.14 years; *SD* =14.80, *n* = 230). On the other hand, scores in the *nonjudging* facet were significantly lower in our samples ($p < 0.05$) compared with those in the community samples (for more details, please refer to Table S1 in Supplementary Information). Spearman's rho correlation analysis indicated a significant negative association between oxytocin levels and the *nonjudging* facet of mindfulness (*rho*= −0.22, $p < 0.05$), and a significant positive association between oxytocin level and the *nonreactivity* facet in FFMQ (*rho* = 0.30, $p < 0.01$), but not other mindfulness facets or resilience level (Table 2).

The ordinary least squares regression models that included the constant, centered oxytocin level, centered resilience level, and their interaction term in predicting the *observing*, *describing*, and *nonreactivity* facets of mindfulness were significant. However, the models that included the same independent variables in predicting the *acting with awareness* and *nonjudging* facets of mindfulness were nonsignificant (Table 3).

Estimations of the significant variables in predicting the *observing*, *describing*, and *nonreactivity* facets of mindfulness were conducted, and results are shown in Table 3. For predicting the *observing* facet, neither the oxytocin level, resilience level, nor their interaction were significant predictors of the *observing* facet. In the model predicting the *describing* facet of mindfulness, only resilience level (unstandardized $\beta = 0.20$, standard error = 0.04, $t = 4.30$, $p < 0.001$, 95% bias-corrected confidence interval ranged from 0.12 to 0.28), but not oxytocin level or their interaction, was found to significantly predict the *describing* facet of mindfulness. In the model predicting the *nonreactivity* facet of mindfulness, oxytocin level (unstandardized $\beta = 0.11$, standard error = 0.04, $t = 3.21$, $p = 0.002$, 95% bias-corrected confidence interval ranged from 0.05 to 0.20), resilience level (unstandardized $\beta = 0.07$, standard error = 0.03, $t = 2.10$, $p = 0.04$, 95% bias-corrected confidence interval ranged from 0.01 to 0.13), and their interaction (unstandardized $\beta = -0.01$, standard error = 0.00, t = -3.13, $p = 0.002$, 95% bias-corrected confidence interval ranged from −0.02 to −0.00) were significant predictors of the *nonreactivity* facet of mindfulness (Table 3). Specifically, the positive association between oxytocin levels and the *nonreactivity*

Table 2 Spearman's rho correlation analysis of oxytocin levels, resilience, and the five facets of mindfulness (*n*= 96)

	CD-RISC	FFMQ-*Observing*	FFMQ-*Describing*	FFMQ-*Acting with awareness*	FFMQ-*Nonjudging*	FFMQ-*Nonreactivity*
Oxytocin levels	0.18	0.09	0.03	−0.14	−0.22*	0.30**
CD-RISC		0.22*	0.40***	0.13	−0.08	0.25*
FFMQ-*Observing*			0.26*	−0.01	−0.29**	0.34***
FFMQ-*Describing*				0.25*	0.01	0.05
FFMQ-*Acting with awareness*					0.41***	−0.28**
FFMQ-*Nonjudging*						−0.27**

CD-RISC Connor-Davidson Resilience Scale, *FFMQ* Five Facet Mindfulness Questionnaire. Numerical data represents the *Rho* values. *p<0.05; **p< 0.01; ***p< 0.001

Table 3 Models' summary and the estimates of the moderation effect of resilience on the relationship between oxytocin levels and each of the five facets of mindfulness. Models included three independent variables namely the mean-centered oxytocin levels, mean-centered resilience levels, and their interaction term in predicting the five facets of mindfulness (outcome variables)

Outcome	*R* (R^2)	*MSE*	*F (df1,df2)*	*p (model)*	*Unstandardized β (SE)*	*t*	*p (estimates)*	*LLCI:ULCI*
FFMQ-*Observing*	0.29 (0.08)	31.70	2.81 (3,92)	0.04*				
Oxytocin					0.03 (0.06)	0.60	0.55	−0.08:0.16
Resilience					0.11 (0.06)	1.96	0.05	−0.00:0.21
Oxytocin x Resilience					−0.01 (0.01)	−1.61	0.11	−0.02:0.00
FFMQ-*Describing*	0.43 (0.18)	24.55	6.77 (3,92)	0.00***				
Oxytocin					−0.00 (0.05)	−0.03	0.98	−0.09:0.09
Resilience					0.20 (0.04)	4.30	0.00***	0.12:0.28
Oxytocin x Resilience					−0.00 (0.01)	−0.18	0.86	−0.01:0.09
FFMQ-*Acting with awareness*	0.22 (0.05)	44.58	1.57 (3,92)	0.20				
Oxytocin					−0.10 (0.09)	−1.48	0.14	−0.31:0.04
Resilience					0.12 (0.06)	1.90	0.06	0.00:0.24
Oxytocin x Resilience					0.01 (0.01)	0.72	0.47	−0.01:0.02
FFMQ-*Nonjudging*	0.24 (0.06)	24.85	1.86 (3,92)	0.14				
Oxytocin					−0.08 (0.06)	−1.64	0.10	−0.21:0.03
Resilience					−0.05 (0.05)	−0.97	0.34	−0.15:0.07
Oxytocin x Resilience					0.01 (0.01)	1.28	0.20	−0.01:0.02
FFMQ-*Nonreactivity*	0.47 (0.22)	12.02	8.52 (3,92)	0.00***				
Oxytocin					0.11 (0.040)	3.21	0.00**	0.05:0.20
Resilience					0.07 (0.030)	2.10	0.04*	0.01:0.13
Oxytocin x Resilience					−0.01 (0.004)	−3.13	0.00**	−0.02:−0.00

FFMQ Five Facet Mindfulness Questionnaire, *MSE* mean squared error, *LLCI* 95% bias-corrected lower bound confidence interval *ULCI* 95% bias-corrected upper bound confidence interval. * $p<0.05$; ** $p< 0.01$; *** $p< 0.001$

facet of mindfulness was diminished with increasing levels of resilience (Fig. 1). At high resilience levels (i.e., 1 standard deviation plus the mean of resilience level), the association between oxytocin levels and the *nonreactivity* facet of mindfulness became non-significant ($p = 0.88$).

Discussion

The current study aimed to investigate the association between oxytocin levels and mindfulness facets as well as the moderation effect of resilience on their associations in a group of local university students. Our findings demonstrated a significant negative association of the salivary oxytocin level with the *nonjudging* facet of dispositional mindfulness, and a significant positive association with the *nonreactivity* facet of dispositional mindfulness in local university students. The moderation analysis further revealed that the positive association between oxytocin and the *nonreactivity* facet of mindfulness was moderated by resilience levels. Specifically, significant positive association between oxytocin and the *nonreactivity* facet of mindfulness was observed only in participants with low or moderate resilience levels and the association became non-significant in high resilient participants.

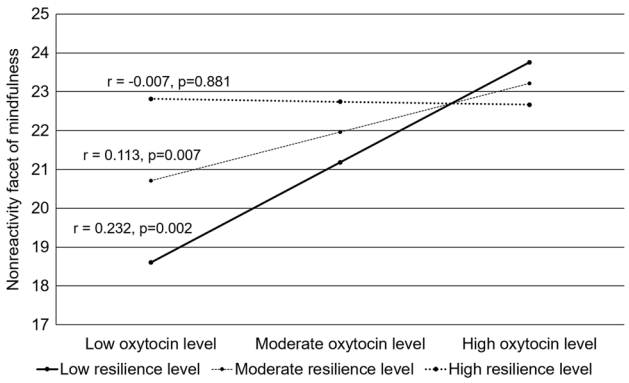

Fig. 1 Association between oxytocin levels and the *nonreactivity* facet of mindfulness score at low, moderate, and high resilience levels. The positive association between the oxytocin level and the *nonreactivity* facet of mindfulness was diminished with the increasing level of resilience (Fig. 1). At high resilience level (i.e., 1 standard deviation plus the mean of resilience level), the association between the oxytocin level and the *nonreactivity* facet of mindfulness became non-significant ($p = 0.88$)

The mean scores of the *describing* and *acting with awareness* in our local university samples were comparable to those of the Chinese community samples (Hou et al., 2014). On the other hand, scores from the *observing* and

nonreactivity facets in our samples were higher than those in the Chinese community samples, whereas scores from the *nonjudging* facet in our samples were lower than those in the Chinese community samples (Hou et al., 2014). Such discrepancy may be explained by the differences in age and education levels between the two samples. For instance, dispositional mindfulness has been reported to be higher in older adults in general (Shook et al., 2017), and when the community samples were mainly middle-aged adults (Hou et al., 2014), whereas our participants were all university students. Education level is another confounding variable to dispositional mindfulness with positive associations of education levels with the *observing*, *describing*, and *nonreactivity* facets of dispositional mindfulness has been reported (Lee & Zelman, 2019). In the community samples, around half of the participants completed primary or secondary school, whereas our participants were all university students. More importantly, the community sample included both meditators ($n = 69$) and non-meditators ($n = 161$), whereas our samples only included non-meditators. Such difference could impact our observed relationships between oxytocin and some of the mindfulness facets as well as the moderation effect of resilience on such relationships, since some mindfulness facets (i.e., *observing*, *nonreactivity*) are suggested to be compared only within populations with a similar level of cultivation of mindfulness (e.g., non-meditators or meditators), but not across populations (e.g., non-meditators versus meditators) (Burzler & Tran, 2022). We, therefore, expect a different finding may not be observed in meditators. As dispositional mindfulness is an important factor contributing to mental well-being, it is essential to understand its underlying biological mechanism that might inform better training paradigms.

In the present study, a significant negative association between oxytocin levels and the *nonjudging* facet of mindfulness was observed. *Nonjudging* of inner experience refers to taking a non-judgmental approach toward one's thoughts and feelings (Baer et al., 2008). Several studies reported the positive association between oxytocin and cognitive appraisal, particularly in social cues, which may explain the negative association between oxytocin and *nonjudging* that we observed in the current study. For instance, oxytocin nasal spray has been shown to improve the accuracy of appraisal of affect from social cues, particularly positive social cues (Guastella & MacLeod, 2012), and reduce negative cognitive appraisal on social distress (Alvares et al., 2012). Similarly, intranasal oxytocin treatment has been shown to increase positive appraisal of one's own overall relationship characteristics (Aguilar-Raab et al., 2019). In addition, salivary oxytocin has been reported to facilitate social awareness by drawing the attention to non-self-socioemotional cues such as facial expressions of others and environmental factors such as circumstances of cooperation versus competition, which helps us navigate social interactions appropriately and make decisions about pro-social or antisocial behavior toward others (Koven & Max, 2014). These findings suggest the involvement of oxytocin in cognitive appraisal that is opposite to the nature of *nonjudging*, which helps explain the negative association between *nonjudging* and salivary oxytocin levels. Nevertheless, *describing* and *nonjudging* were reported to be the only mindfulness facets that facilitate cognitive reappraisal (positive appraisal) resulting in an enhancement in resilience (Jones et al., 2019). Future studies are warranted to further understand the association of *nonjudging* with cognitive appraisal and reappraisal as well as the involvement of oxytocin. For instance, a randomized controlled trial can be conducted to investigate the effect of oxytocin nasal spray versus placebo on the ability of nonjudging, cognitive appraisal, and reappraisal as well as their concurrent changes.

Nonreactivity to inner experience is the tendency to witness feelings and thoughts come and go without being carried away by them, that is, without reacting (Baer et al., 2008). A significant positive association between oxytocin level and the *nonreactivity* facet of mindfulness was observed. Nonreactivity is known to buffer the reactivity to stress; improving the *nonreactivity* facet after mindfulness training helps reduce depression symptoms (Zou et al., 2020). High levels of *nonreactivity* facilitates the process to disengage from established but unhelpful responses by promoting mental states adaptively, inhibiting habitual responses or non-reacting which in turn gives time to generate new appraisals and solutions to challenging situations (Zou et al., 2020). It has been reported that *nonreactivity* is positively related to reappraisal and acceptance (Iani et al., 2019). The positive association between the *nonreactivity* facet of dispositional mindfulness and oxytocin may be explained by their mutual involvement in positive appraisal. Furthermore, oxytocin release from the oxytocinergic system is crucial for the mediation of self-soothing behaviors. Oxytocin release can be triggered by pleasant mental experiences such as positive thinking (e.g., thinking of a well-known or beloved person) or other pleasant situations, which inhibits the activity of noradrenergic neurons in the central nervous system leading to an anti-stress response (Uvnäs-Moberg et al., 2015). In this context, our results show a positive correlation between *nonreactivity* to inner experience and oxytocin levels which suggests that observing the inner experience without reacting could stimulate oxytocin release and have a self-soothing effect mediated by oxytocin.

The results of the ordinary least squares regression models demonstrated further that the positive association between *nonreactivity* and oxytocin was moderated by resilience levels. Specifically, the positive association between *nonreactivity* and oxytocin was observed only in participants with low to moderate levels of resilience

but not in high resilient participants. The results indicate that oxytocin is important in contributing to *nonreactivity* when resilience levels are low. The oxytocin system facilitates adaptation, integration, and stability in changing environments; thus, it plays an important role in developing resilience (Takayanagi & Onaka, 2022). Previous studies have shown the buffering effect of oxytocin on stress reactivity (Love, 2018; Simeon et al., 2011), which is in line to the association between *nonreactivity* and oxytocin found in the present study. However, this association is only present in individuals with low resilience, which suggests that the role of the oxytocin system and the *nonreactivity* facet of mindfulness in individuals with low resilience is more significant. Building resilience may involve different resources and systems that work in conjunction in a direct or indirect, by acting on other subsystems, manner in order to enhance flexibility and resilience in the entire system (Feldman, 2021). Our results suggest that resources such as the oxytocin system and the *nonreactivity* facet of mindfulness are more significant resources that can be used in individuals with low resilience. Previous studies have shown that resilience mediates positive outcomes of mindfulness. For instance, a study on nursing students has shown that resilience mediates the negative relationship between dispositional mindfulness and burnout (Rees et al., 2015). Similarly, another study has shown that resilience mediates the negative relationship between mindfulness and stress (Bajaj et al., 2022). In addition, mindfulness and resilience has been previously reported to predict around 50% of the variance of psychological well-being in university students (Pidgeon & Keye, 2014). A study reported that low resilience levels tend to lead to increased gains following a mindfulness-based intervention opposite to what was observed in individuals with high resilience (Barczak-Scarboro et al., 2021). Evidence from previous studies and the moderating effect of resilience observed in this study suggest that mechanisms, such as pro-social behavior regulated by oxytocin, may be adopted by individuals with high levels of resilience rather than mindfulness.

In this study, the emphasis was on exploring the association between oxytocin, resilience, and dispositional mindfulness in university students. High trait mindfulness is associated with better cognitive functions and academic performance in college students (McBride & Greeson, 2023). Furthermore, cultivation of mindfulness and resilience are important for college students to buffer from distress encountered through university education and their future workplaces (Ng & Kong, 2022). Mindfulness-based programs, therefore, are recommended in university curricula. Our findings added to the literature that students with low to moderate resilience levels might be benefit more from these programs.

Limitations and Future Research

There are several limitations in this study. First, the saliva samples were collected after completing the questionnaires. The influence of the questionnaire task on the level of salivary oxytocin is unknown. According to the literature, most tasks that induced a fast release (below 30 min) of oxytocin involved proprioceptive stimulations (de Jong et al., 2015; Geva et al., 2020). On the other hand, stress-induced oxytocin release requires at least 30 min to elevate plasma oxytocin, which may take even longer to capture in saliva samples (Comes-Fayos et al., 2022; de Jong et al., 2015; Pierrehumbert et al., 2010). In our experiment, the duration of our participants to take the questionnaire before collecting the saliva samples was no more than 20 min. We, therefore, consider the effect of the questionnaire task on the level of salivary oxytocin to be minimal in our experiment. Nevertheless, future studies should consider collecting salivary samples before any tasks to be conducted in order to minimize any effect on the release of oxytocin. Moreover, although the moderation analysis provides valuable information on the hypothetical causal relationship among oxytocin, resilience, and mindfulness, the interpretation of findings is limited by the cross-sectional nature of the study. Clinical validations are, therefore, needed to evaluate the relationship among the variables and the mechanism behind the association. To prove the causal relationship, randomized controlled trials would be desired to determine the changes of oxytocin level before and after meditation practice in participants with different resilience levels. Double-blinded intranasal oxytocin versus placebo treatment could also be considered to determine the effect of oxytocin on mindfulness changes in participants with different resilience level. Last but not least, the current study relied on the use of self-report questionnaires to measure mindfulness, in which subjective bias is inevitable. Future studies may consider supplementing with the breath counting task (Levinson et al., 2014) as a more objective measure of mindfulness to more comprehensively capture mindfulness.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12671-023-02186-5.

Author Contribution WKWL contributed to the study conception and design, data collection and analysis, manuscript writing, and writing review and editing. DISV contributed to manuscript writing and writing review and editing. APLT, JNMC, and LHMN contributed to data collection. All authors contributed to the writing review and editing. All authors read and approved the final manuscript.

Funding This study was supported by the Early Career Scheme from the University Grants Committee (awarded to WKWL; Ref no: 28602319), and the Research Area Based Seed Fund from The Hong Kong Polytechnic University (awarded to BWML; Ref no: P0033824).

Declarations

Ethics Approval The procedure was approved by the Research Ethics Committee of EdUHK (Ref no. 2018-2019-0117) and followed the Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects.

Conflict of Interest The authors declare no competing interests.

References

Aguilar-Raab, C., Eckstein, M., Geracitano, S., Prevost, M., Gold, I., Heinrichs, M., Bilderbeck, A., Ehlert, U., & Ditzen, B. (2019). Oxytocin modulates the cognitive appraisal of the own and others close intimate relationships. *Frontiers in Neuroscience, 13*, 714. https://doi.org/10.3389/fnins.2019.00714

Alvares, G. A., Chen, N. T. M., Balleine, B. W., Hickie, I. B., & Guastella, A. J. (2012). Oxytocin selectively moderates negative cognitive appraisals in high trait anxious males. *Psychoneuroendocrinology, 37*(12), 2022–2031. https://doi.org/10.1016/j.psyneuen.2012.04.018

American Psychological Association. (2022). *Resilience*. https://www.apa.org/topics/resilience

Auerbach, R. P., Alonso, J., Axinn, W. G., Cuijpers, P., Ebert, D. D., Green, J. G., Hwang, I., Kessler, R. C., Liu, H., Mortier, P., Nock, M. K., Pinder-Amaker, S., Sampson, N. A., Aguilar-Gaxiola, S., Al-Hamzawi, A., Andrade, L. H., Benjet, C., Caldas-de-Almeida, J. M., Demyttenaere, K., et al. (2016). Mental disorders among college students in the World Health Organization World Mental Health Surveys. *Psychological Medicine, 46*(14), 2955–2970. https://doi.org/10.1017/S0033291716001665

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment, 13*(1), 27–45. https://doi.org/10.1177/1073191105283504

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., Walsh, E., Duggan, D., & Williams, J. M. G. (2008). Construct validity of the Five Facet Mindfulness Questionnaire in meditating and nonmeditating samples. *Assessment, 15*(3), 329–342. https://doi.org/10.1177/1073191107313003

Bajaj, B., Khoury, B., & Sengupta, S. (2022). Resilience and stress as mediators in the relationship of mindfulness and happiness. *Frontiers in Psychology, 13*, 771263. https://doi.org/10.3389/fpsyg.2022.771263

Barczak-Scarboro, N. E., Van Cappellen, P., & Fredrickson, B. L. (2021). For whom do meditation interventions improve mental health symptoms? Looking at the roles of psychological and biological resources over time. *Mindfulness, 12*(11), 2781–2793. https://doi.org/10.1007/s12671-021-01742-1

Bellosta-Batalla, M., Blanco-Gandía, M. C., Rodríguez-Arias, M., Cebolla, A., Pérez-Blasco, J., & Moya-Albiol, L. (2020). Increased salivary oxytocin and empathy in students of clinical and health psychology after a mindfulness and compassion-based intervention. *Mindfulness, 11*(4), 1006–1017. https://doi.org/10.1007/s12671-020-01316-7

Bellosta-Batalla, M., del Carmen Blanco-Gandía, M., Rodríguez-Arias, M., Cebolla, A., Pérez-Blasco, J., & Moya-Albiol, L. (2020). Brief mindfulness session improves mood and increases salivary oxytocin in psychology students. *Stress and Health, 36*(4), 469–477. https://doi.org/10.1002/smi.2942

Bowlin, S. L. (2012). Dispositional mindfulness and self-compassion and their influence on oxytocin and parasympathetic functioning [Thesis, University of Kansas]. https://kuscholarworks.ku.edu/handle/1808/10872

Bravo, A. J., Boothe, L. G., & Pearson, M. R. (2016). Getting personal with mindfulness: A latent profile analysis of mindfulness and psychological outcomes. *Mindfulness, 7*(2), 420–432. https://doi.org/10.1007/s12671-015-0459-7

Bravo, A. J., Pearson, M. R., & Kelley, M. L. (2018). Mindfulness and psychological health outcomes: A latent profile analysis among military personnel and college students. *Mindfulness, 9*(1), 258. https://doi.org/10.1007/s12671-017-0771-5

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*(4), 822–848. https://doi.org/10.1037/0022-3514.84.4.822

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*(4), 211–237. https://doi.org/10.1080/10478400701598298

Burzler, M. A., & Tran, U. S. (2022). Dispositional mindfulness and the process of mindfulness cultivation: A qualitative synthesis and critical assessment of the extant literature on the Five Facet Mindfulness Questionnaire (FFMQ). *Collabra: Psychology, 8*(1), 56176. https://doi.org/10.1525/collabra.56176

Cage, E., Jones, E., Ryan, G., Hughes, G., & Spanner, L. (2021). Student mental health and transitions into, through and out of university: Student and staff perspectives. *Journal of Further and Higher Education, 45*(8), 1076–1089. https://doi.org/10.1080/0309877X.2021.1875203

Calvete, E., Morea, A., & Orue, I. (2019). The role of dispositional mindfulness in the longitudinal associations between stressors, maladaptive schemas, and depressive symptoms in adolescents. *Mindfulness, 10*(3), 547–558. https://doi.org/10.1007/s12671-018-1000-6

Churchland, P. S., & Winkielman, P. (2012). Modulating social behavior with oxytocin: How does it work? What does it mean? *Hormones and Behavior, 61*(3), 392–399. https://doi.org/10.1016/j.yhbeh.2011.12.003

Comes-Fayos, J., Blanco-Gandía, M. C., Moreno, I. R., Rodríguez-Arias, M., Lila, M., Sarrate-Costa, C., Romero-Martínez, A., & Moya-Albiol, L. (2022). Reduced salivary oxytocin after an empathic induction task in intimate partner violence perpetrators: Importance of socio-affective functions and its impact on prosocial behavior. *Psychoneuroendocrinology, 137*, 105644. https://doi.org/10.1016/j.psyneuen.2021.105644

Condon, P. (2019). Meditation in context: Factors that facilitate prosocial behavior. *Current Opinion in Psychology, 28*, 15–19. https://doi.org/10.1016/j.copsyc.2018.09.011

Connor, K. M., & Davidson, J. R. T. (2003). Development of a new resilience scale: The Connor-Davidson Resilience Scale (CD-RISC). *Depression and Anxiety, 18*(2), 76–82. https://doi.org/10.1002/da.10113

Davydov, D. M., Stewart, R., Ritchie, K., & Chaudieu, I. (2010). Resilience and mental health. *Clinical Psychology Review, 30*(5), 479–495. https://doi.org/10.1016/j.cpr.2010.03.003

de Jong, T. R., Menon, R., Bludau, A., Grund, T., Biermeier, V., Klampfl, S. M., Jurek, B., Bosch, O. J., Hellhammer, J., & Neumann, I. D. (2015). Salivary oxytocin concentrations in response to running, sexual self-stimulation, breastfeeding and the TSST: The Regensburg Oxytocin Challenge (ROC) study. *Psychoneuroendocrinology, 62*, 381–388. https://doi.org/10.1016/j.psyneuen.2015.08.027

Dickenson, J. A., Alley, J., & Diamond, L. M. (2019). Subjective and oxytocinergic responses to mindfulness are associated with subjective and oxytocinergic responses to sexual arousal. *Frontiers in Psychology, 10*, 1101. https://doi.org/10.3389/fpsyg.2019.01101

Donald, J. N., Sahdra, B. K., Van Zanden, B., Duineveld, J. J., Atkins, P. W. B., Marshall, S. L., & Ciarrochi, J. (2019). Does your mindfulness benefit others? A systematic review and meta-analysis of the link between mindfulness and prosocial behaviour. *British Journal of Psychology, 110*(1), 101–125. https://doi.org/10.1111/bjop.12338

Duffy, A., Saunders, K. E. A., Malhi, G. S., Patten, S., Cipriani, A., McNevin, S. H., MacDonald, E., & Geddes, J. (2019). Mental health care for university students: A way forward? *The Lancet Psychiatry, 6*(11), 885–887. https://doi.org/10.1016/S2215-0366(19)30275-5

Feldman, R. (2020). What is resilience: An affiliative neuroscience approach. *World Psychiatry, 19*(2), 132–150. https://doi.org/10.1002/wps.20729

Feldman, R. (2021). Social behavior as a transdiagnostic marker of resilience. *Annual Review of Clinical Psychology, 17*(1), 153–180. https://doi.org/10.1146/annurev-clinpsy-081219-102046

Geva, N., Uzefovsky, F., & Levy-Tzedek, S. (2020). Touching the social robot PARO reduces pain perception and salivary oxytocin levels. *Scientific Reports, 10*, 9814. https://doi.org/10.1038/s41598-020-66982-y

Guastella, A. J., & MacLeod, C. (2012). A critical review of the influence of oxytocin nasal spray on social cognition in humans: Evidence and future directions. *Hormones and Behavior, 61*(3), 410–418. https://doi.org/10.1016/j.yhbeh.2012.01.002

Hayes, A. F., & Preacher, K. J. (2013). Conditional process modeling: Using structural equation modeling to examine contingent causal processes. In *Structural equation modeling: A second course* (2nd ed., pp. 219–266). IAP Information Age Publishing.

Hoehne, K., Vrtička, P., Engert, V., & Singer, T. (2022). Plasma oxytocin is modulated by mental training, but does not mediate its stress-buffering effect. *Psychoneuroendocrinology, 141*, 105734. https://doi.org/10.1016/j.psyneuen.2022.105734

Hou, J., Wong, S. Y.-S., Lo, H. H.-M., Mak, W. W.-S., & Ma, H. S.-W. (2014). Validation of a Chinese version of the Five Facet Mindfulness Questionnaire in Hong Kong and development of a short form. *Assessment, 21*(3), 363–371. https://doi.org/10.1177/1073191113485121

Iani, L., Lauriola, M., Chiesa, A., & Cafaro, V. (2019). Associations between mindfulness and emotion regulation: The key role of describing and nonreactivity. *Mindfulness, 10*(2), 366–375. https://doi.org/10.1007/s12671-018-0981-5

Jones, S. M., Bodie, G. D., & Hughes, S. D. (2019). The impact of mindfulness on empathy, active listening, and perceived provisions of emotional support. *Communication Research, 46*(6), 838–865. https://doi.org/10.1177/0093650215626983

Kalisch, R., Cramer, A. O. J., Binder, H., Fritz, J., Leertouwer, I., Lunansky, G., Meyer, B., Timmer, J., Veer, I. M., & van Harmelen, A.-L. (2019). Deconstructing and reconstructing resilience: A dynamic network approach. *Perspectives on Psychological Science, 14*(5), 765–777. https://doi.org/10.1177/1745691619855637

Kessler, R. C., Amminger, G. P., Aguilar-Gaxiola, S., Alonso, J., Lee, S., & Üstün, T. B. (2007). Age of onset of mental disorders: A review of recent literature. *Current Opinion in Psychiatry, 20*(4), 359–364. https://doi.org/10.1097/YCO.0b013e32816ebc8c

Kil, H., O'Neill, D., & Grusec, J. E. (2021). Prosocial motivation as a mediator between dispositional mindfulness and prosocial behavior. *Personality and Individual Differences, 177*, 110806. https://doi.org/10.1016/j.paid.2021.110806

Koven, N. S., & Max, L. K. (2014). Basal salivary oxytocin level predicts extra- but not intra-personal dimensions of emotional intelligence. *Psychoneuroendocrinology, 44*, 20–29. https://doi.org/10.1016/j.psyneuen.2014.02.018

La Fratta, I., Franceschelli, S., Speranza, L., Patruno, A., Michetti, C., D'Ercole, P., Ballerini, P., Grilli, A., & Pesce, M. (2021). Salivary oxytocin, cognitive anxiety and self-confidence in pre-competition athletes. *Scientific Reports, 11*, 16877. https://doi.org/10.1038/s41598-021-96392-7

Lau, W. K. W. (2022). The role of resilience in depression and anxiety symptoms: A three-wave cross-lagged study. *Stress and Health, 38*(4), 804–812. https://doi.org/10.1002/smi.3136

Lau, W. K. W., Tai, A. P. L., Chan, J. N. M., Lau, B. W. M., & Geng, X. (2021). Integrative psycho-biophysiological markers in predicting psychological resilience. *Psychoneuroendocrinology, 129*, 105267. https://doi.org/10.1016/j.psyneuen.2021.105267

Leary, K. A., & DeRosier, M. E. (2012). Factors promoting positive adaptation and resilience during the transition to college. *Psychology, 3*(12), 12. https://doi.org/10.4236/psych.2012.312A180

Lecuona, O., García-Rubio, C., de Rivas, S., Moreno-Jiménez, J. E., Meda-Lara, R. M., & Rodríguez-Carvajal, R. (2021). A network analysis of the Five Facets Mindfulness Questionnaire (FFMQ). *Mindfulness, 12*(9), 2281–2294. https://doi.org/10.1007/s12671-021-01704-7

Lee, F. K. S., & Zelman, D. C. (2019). Boredom proneness as a predictor of depression, anxiety and stress: The moderating effects of dispositional mindfulness. *Personality and Individual Differences, 146*, 68–75. https://doi.org/10.1016/j.paid.2019.04.001

Levecque, K., Anseel, F., De Beuckelaer, A., Van der Heyden, J., & Gisle, L. (2017). Work organization and mental health problems in PhD students. *Research Policy, 46*(4), 868–879. https://doi.org/10.1016/j.respol.2017.02.008

Levinson, D. B., Stoll, E. L., Kindy, S. D., Merry, H. L., & Davidson, R. J. (2014). A mind you can count on: Validating breath counting as a behavioral measure of mindfulness. *Frontiers in Psychology, 5*, 1202. https://doi.org/10.3389/fpsyg.2014.01202

Love, T. M. (2018). The impact of oxytocin on stress: The role of sex. *Current Opinion in Behavioral Sciences, 23*, 136–142. https://doi.org/10.1016/j.cobeha.2018.06.018

McBride, E. E., & Greeson, J. M. (2023). Mindfulness, cognitive functioning, and academic achievement in college students: The mediating role of stress. *Current Psychology, 42*, 10924–10934. https://doi.org/10.1007/s12144-021-02340-z

Medvedev, O. N., Krägeloh, C. U., Narayanan, A., & Siegert, R. J. (2017). Measuring mindfulness: Applying generalizability theory to distinguish between state and trait. *Mindfulness, 8*(4), 1036–1046. https://doi.org/10.1007/s12671-017-0679-0

Mohr, C., Braun, S., Bridler, R., Chmetz, F., Delfino, J. P., Kluckner, V. J., Lott, P., Schrag, Y., Seifritz, E., & Stassen, H. H. (2014). Insufficient coping behavior under chronic stress and vulnerability to psychiatric disorders. *Psychopathology, 47*(4), 235–243. https://doi.org/10.1159/000356398

Ng, B., & Kong, L. C. (2022). Graduate resilience in future workplace: Mindfulness-based research on personality traits, trait affect and resilience. In B. Ng (Ed.), *Higher Education and Job Employability* (pp. 255–285). Springer. https://doi.org/10.1007/978-3-031-05716-8_13

Ozbay, F., Johnson, D. C., Dimoulas, E., Morgan, C. A., Charney, D., & Southwick, S. (2007). Social support and resilience to stress: From neurobiology to clinical practice. *Psychiatry, 4*(5), 35–40.

Pedrelli, P., Nyer, M., Yeung, A., Zulauf, C., & Wilens, T. (2015). College students: Mental health problems and treatment considerations. *Academic Psychiatry, 39*(5), 503–511. https://doi.org/10.1007/s40596-014-0205-9

Pelham, W. E., Gonzalez, O., Metcalf, S. A., Whicker, C. L., Witkiewitz, K., Marsch, L. A., & Mackinnon, D. P. (2019). Evaluating the factor structure of each facet of the Five Facet Mindfulness Questionnaire. *Mindfulness, 10*(12), 2629–2646. https://doi.org/10.1007/s12671-019-01235-2

Pidgeon, A. M., & Keye, M. (2014). Relationship between resilience, mindfulness, and psychological well-being in university students. *International Journal of Liberal Arts and Social Science, 2*(5), 27–32.

Pierrehumbert, B., Torrisi, R., Laufer, D., Halfon, O., Ansermet, F., & Beck Popovic, M. (2010). Oxytocin response to an experimental psychosocial challenge in adults exposed to traumatic experiences during childhood or adolescence. *Neuroscience, 166*(1), 168–177. https://doi.org/10.1016/j.neuroscience.2009.12.016

Pilot, D. F., & Beck, C. T. (2006). Essentials of nursing research: Methods, appraisal, and utilization. *Nurse Researcher, 13*(4), 91–92. https://doi.org/10.7748/nr.13.4.91.s11

Ramasubramanian, S. (2017). Mindfulness, stress coping and everyday resilience among emerging youth in a university setting: A mixed methods approach. *International Journal of Adolescence and Youth, 22*(3), 308–321. https://doi.org/10.1080/02673843.2016.1175361

Ratanasiripong, P., China, T., & Toyama, S. (2018). Mental Health and well-being of university students in Okinawa. *Education Research International, 2018*, e4231836. https://doi.org/10.1155/2018/4231836

Rees, C. S., Breen, L. J., Cusack, L., & Hegney, D. (2015). Understanding individual resilience in the workplace: the international collaboration resilience model. *Frontiers in Psychology, 6*, 73. https://doi.org/10.3389/fpsyg.2015.00073

Sharma, S. R., Gonda, X., Dome, P., & Tarazi, F. I. (2020). What's love got to do with it: Role of oxytocin in trauma, attachment and resilience. *Pharmacology & Therapeutics, 214*, 107602. https://doi.org/10.1016/j.pharmthera.2020.107602

Shook, N. J., Ford, C., Strough, J., Delaney, R., & Barker, D. (2017). In the moment and feeling good: Age differences in mindfulness and positive affect. *Translational Issues in Psychological Science, 3*, 338–347. https://doi.org/10.1037/tps0000139

Simeon, D., Bartz, J., Hamilton, H., Crystal, S., Braun, A., Ketay, S., & Hollander, E. (2011). Oxytocin administration attenuates stress reactivity in borderline personality disorder: A pilot study. *Psychoneuroendocrinology, 36*(9), 1418–1421. https://doi.org/10.1016/j.psyneuen.2011.03.013

Solmi, M., Radua, J., Olivola, M., Croce, E., Soardo, L., Salazar de Pablo, G., Il Shin, J., Kirkbride, J. B., Jones, P., Kim, J. H., Kim, J. Y., Carvalho, A. F., Seeman, M. V., Correll, C. U., & Fusar-Poli, P. (2022). Age at onset of mental disorders worldwide: Large-scale meta-analysis of 192 epidemiological studies. *Molecular Psychiatry, 27*(1), 1. https://doi.org/10.1038/s41380-021-01161-7

Stallman, H. M. (2010). Psychological distress in university students: A comparison with general population data. *Australian Psychologist, 45*(4), 249–257. https://doi.org/10.1080/00050067.2010.482109

Stefan, S., & David, D. (2020). Mindfulness in therapy: A critical analysis. *International Journal of Clinical and Experimental Hypnosis, 68*(2), 167–182. https://doi.org/10.1080/00207144.2020.1720514

Takayanagi, Y., & Onaka, T. (2022). Roles of oxytocin in stress responses, allostasis and resilience. *International Journal of Molecular Sciences, 23*(1), 1. https://doi.org/10.3390/ijms23010150

Tanay, G., & Bernstein, A. (2013). State Mindfulness Scale (SMS): Development and initial validation. *Psychological Assessment, 25*, 1286–1299. https://doi.org/10.1037/a0034044

Tang, A. L., Thomas, S. J., & Larkin, T. (2019). Cortisol, oxytocin, and quality of life in major depressive disorder. *Quality of Life Research, 28*(11), 2919–2928. https://doi.org/10.1007/s11136-019-02236-3

Uvnäs-Moberg, K., Handlin, L., & Petersson, M. (2015). Self-soothing behaviors with particular reference to oxytocin release induced by non-noxious sensory stimulation. *Frontiers in Psychology, 5*, 1529. https://doi.org/10.3389/fpsyg.2014.01529

Wang, X., Hegde, S., Son, C., Keller, B., Smith, A., & Sasangohar, F. (2020). Investigating mental health of US college students during the COVID-19 pandemic: Cross-sectional survey study. *Journal of Medical Internet Research, 22*(9), e22817. https://doi.org/10.2196/22817

Xiaonan, Y., & Jianxin, Z. (2007). A comparison between the Chinese version of Ego-Resiliency Scale and Connor-Davidson Resilience Scale. *Psychological Science (China), 30*, 1169–1171.

Yang, F., & Oka, T. (2022). The role of mindfulness and attachment security in facilitating resilience. *BMC Psychology, 10*(1), 69. https://doi.org/10.1186/s40359-022-00772-1

Young Kuchenbecker, S., Pressman, S. D., Celniker, J., Grewen, K. M., Sumida, K. D., Jonathan, N., Everett, B., & Slavich, G. M. (2021). Oxytocin, cortisol, and cognitive control during acute and naturalistic stress. *Stress, 24*(4), 370–383. https://doi.org/10.1080/10253890.2021.1876658

Zhou, H.-X., Chen, X., Shen, Y.-Q., Li, L., Chen, N.-X., Zhu, Z.-C., Castellanos, F. X., & Yan, C.-G. (2020). Rumination and the default mode network: Meta-analysis of brain imaging studies and implications for depression. *NeuroImage, 206*, 116287. https://doi.org/10.1016/j.neuroimage.2019.116287

Zou, Y., Li, P., Hofmann, S. G., & Liu, X. (2020). The mediating role of non-reactivity to mindfulness training and cognitive flexibility: A randomized controlled trial. *Frontiers in Psychology, 11*, 1053. https://doi.org/10.3389/fpsyg.2020.01053