



# Effects of an incremental theory of the personality intervention on psychophysiological responses to social stress during the transition to college

Esther Calvete<sup>1</sup> · Izaskun Orue<sup>1</sup> · Angel Prieto-Fidalgo<sup>1</sup> · Joana Gómez-Odrizola<sup>1</sup> · Sven C. Mueller<sup>1</sup> · Estibaliz Royuela-Colomer<sup>1</sup> · Aida Morea<sup>1</sup> · Eneko Ruiz-Alonso<sup>1</sup> · Maite Larrucea-Iruretagoyena<sup>1</sup> · Todd D. Little<sup>2,3</sup> · Liria Fernández-González<sup>1</sup>

Accepted: 28 December 2021 / Published online: 4 January 2022  
© The Author(s) 2022

## Abstract

This randomized controlled trial (NCT04786496) examined the effects of a preventive intervention based on Incremental Theory of the Personality (ITP) on psychophysiological responses to social stress and evaluated whether levels of depression moderate the intervention effects. The participants, 107 first-year university students, were randomly assigned to one of three conditions: ITP intervention, ITP + a self-affirmation intervention (SA), and a control condition (CC). Indicators of the Hypothalamic–Pituitary–Adrenal axis, autonomic nervous system, and subjective mood were assessed with the Trier Social Stress Task. Participants in the ITP condition displayed a lower decline in respiratory sinus arrhythmia (RSA) compared to those in the CC during the first phases of the task [Slopes:  $-0.08_{(0.09)}$  vs  $-0.21_{(0.09)}$ ,  $z = 2.86$ ,  $p = .004$ ] and a higher decrease in cortisol at recovery [ $\beta = -0.18_{(0.08)}$ ,  $z = -2.37$ ,  $p = .018$ ]. Depressive symptoms moderated the effect of ITP [ $\beta = -0.10_{(0.05)}$ ,  $z = -2.15$ ,  $p = .032$ ] and ITP+SA [ $\beta = -0.09_{(0.04)}$ ,  $z = -2.06$ ,  $p = .039$ ] in the decline during stress and recovery in RSA. In participants with low/medium levels of depressive symptoms, both interventions predicted a lower decline during stress [Slopes:  $-0.06_{(0.09)}$  for ITP,  $-0.17_{(0.09)}$  for ITP+SA, and  $-0.26_{(0.09)}$  for CC] and higher recovery in RSA [Slopes:  $0.18_{(0.01)}$  for ITP,  $0.24_{(0.01)}$  for ITP+SA, and  $0.30_{(0.01)}$  for CC]. The findings suggest that the ITP intervention has the potential to be an effective preventive intervention to reduce the stress response.

**Keywords** depressive symptoms · Incremental Theory of the Personality · respiratory sinus arrhythmia · cortisol · Trier Social Stress Task

Dysregulated reactivity to stress has been proposed as a key etiological factor for depression (Lucas-Thompson et al., 2018). Thus, the development of more regulated neurobiological responses to stress could aid preventive efforts contributing to the reduction of depression. However, research on the effects of preventive interventions for depression on neurobiological responses to stress is scarce. This study examines the effects of a brief preventive intervention based

on implicit theories of personality (Miu & Yeager, 2015) on several markers of stress reactivity.

## Neurobiological responses to stress and depression

Two main stress pathways are activated during stress exposure: the autonomic nervous system (ANS) and the Hypothalamic–Pituitary–Adrenal (HPA) axis. The ANS is comprised of the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS), which work jointly to regulate the body's stress response. Whereas the SNS is measured by biomarkers, such as heart rate (HR) and skin conductance level (SCL) (Bauerly et al., 2019), PNS activation is measured by respiratory sinus arrhythmia (RSA), a metric of high-frequency heart rate variability

✉ Esther Calvete  
esther.calvete@deusto.es

<sup>1</sup> Department of Psychology, University of Deusto, Avenida de las Universidades, 24, 48007 Bilbao, Spain

<sup>2</sup> Texas Tech University, Lubbock, TX, USA

<sup>3</sup> Optentia Research Focus Area, North-West University, Vanderbijlpark, South Africa

(HF-HRV) that refers to variation in heart rate across the respiratory cycle. Overall, more effective regulation of the stress response is indicated by a higher baseline level and less reactive RSA during stress (Goger et al., 2020). The second stress pathway, the HPA axis, includes increases in cortisol, a widely used biochemical marker of stress (Fiksdal et al., 2020; Pulopulos et al., 2020).

A systematic review revealed that individuals high in depressive symptoms show a response pattern similar to that of healthy participants (i.e., a lower fluctuation in heart rate and RSA) but with a lower magnitude both in stress and recovery situations (Schiweck et al., 2019). This was interpreted as a lack of cardiovascular modulation in the response to stress. In addition, although the evidence is inconclusive, depressive symptoms are associated with dysregulated HPA axis functioning in response to stress (Fiksdal et al., 2020).

### Incremental theory of personality interventions for depression

The average effect of universal preventive interventions for depression is small and often not significant for young people (Stice et al., 2006), mainly because they may be long, boring, and create tiredness (Schleider & Weisz, 2017; Yeager et al., 2018). Another difficulty derives from the inherent resistance of adolescents and young people to programmatic attempts to modify their behavior (Yeager et al., 2018). To counter this problem, recent preventive attempts focused on what are known as wise interventions (Walton & Wilson, 2018). These brief interventions can elicit significant changes in relatively stable individual characteristics (e.g., emotional well-being and social integration) based on strategies derived from research on persuasion and attitude change. Because wise interventions are generally minimally directive and provide well-designed reflection exercises, they allow people to draw new conclusions for themselves (Walton & Wilson, 2018). Thus, with wise interventions, adolescents and young people are less likely to react with resistance (Yeager et al., 2018).

Several wise interventions have focused on mindsets or implicit theories about the malleability of personal qualities such as intelligence (Yeager et al., 2019), stress (Crum et al., 2013), and personality (Yeager et al., 2013). Implicit theories refer to the beliefs about the malleability of personal attributes (Sung et al., 2020). The intervention based on implicit theories of personality (Miu & Yeager, 2015; Yeager et al., 2013) was developed to reduce depressive symptoms in adolescents. This intervention consisted of developing an incremental theory of the personality (ITP), that is, the idea that people can change. One of the versions tested by Yeager and colleagues included a single session lasting about one hour, with positive results in terms of

reducing symptoms of depression in nine months postintervention (Miu & Yeager, 2015). The beneficial findings of this single-session ITP intervention have been replicated in other studies with clinical (Schleider & Weisz, 2018) and non-clinical samples (Calvete et al., 2019) with nine-month and one-year follow-ups, respectively.

To further improve the effectiveness of the ITP intervention, others have combined it with a self-affirmation (SA) intervention (Cohen & Sherman, 2014; Steele, 1988). SA interventions use tasks that activate positive self-concept components. They seek to make individuals feel competent and more motivated to accept persuasive messages to change their behavior (Good & Abraham, 2011). SA has been proven to be an effective psychological technique for reducing resistance and increasing intervention effectiveness across multiple domains (Falk et al., 2015). Particularly in the field of ITP interventions, the combination of ITP+SA was more effective than ITP alone in reducing risky Internet behaviors three-months later (Calvete et al., 2020). However, the joint action of both interventions has not been proven in the field of stress reactivity and depression. As an exception, Osborn and colleagues compared an intervention that included ITP, gratitude techniques, and self-affirmation with a study skills control group and found a greater reduction in anxiety and depression in the experimental group in a two-week follow-up. However, they did not compare ITP alone with the combination of ITP+SA (Osborn et al., 2020a; Osborn et al., 2020b).

Surprisingly, although it has been proposed that one route by which the ITP intervention reduces depression is by enhancing more adaptive neurobiological responses to stress (Yeager et al., 2016), evidence is scarce. Yeager et al. (2016) found that, when exposed to a lab stressor, adolescents receiving the ITP intervention displayed lower cortisol reactivity and less SNS activation at recovery than control participants. In another study, the ITP intervention reduced cortisol levels in a 1-year follow-up among adolescents (Calvete et al., 2019).

### The current study

This study aimed to elucidate the effects of ITP, both alone and combined with SA, on neurobiological and mood responses to social stress in young adults. Responses included a change in ANS indicators (HR, SCL, and RSA), cortisol level, and positive and negative mood. Based on preliminary findings (Calvete et al., 2019, 2020), three conditions were compared in response to a standardized social stressor (the Trier Social Stress Test, TSST; Kirschbaum et al., 1993): the effects of 1) ITP alone and 2) ITP+SA compared to 3) a control condition (CC). During the TSST, ANS indicators (HR, SCL, RSA), cortisol level, and subjective

mood were recorded. We expected that participants in both ITP interventions, and in the ITP+SA intervention in particular, would display more regulated stress responses (i.e., lower HR and SCL increase, lower RSA suppression, and lower cortisol and negative mood increase) when compared to the CC. We also expected that they would display better recovery after the stressful tasks (i.e., higher HR and SCL decrease and higher RSA increase). Moreover, we anticipated that this effect would be particularly pronounced in participants with more depressive symptoms, given that some studies have found that interventions are more effective for participants at risk of depression (Bower et al., 2013).

## Material and methods

### Study design and participants

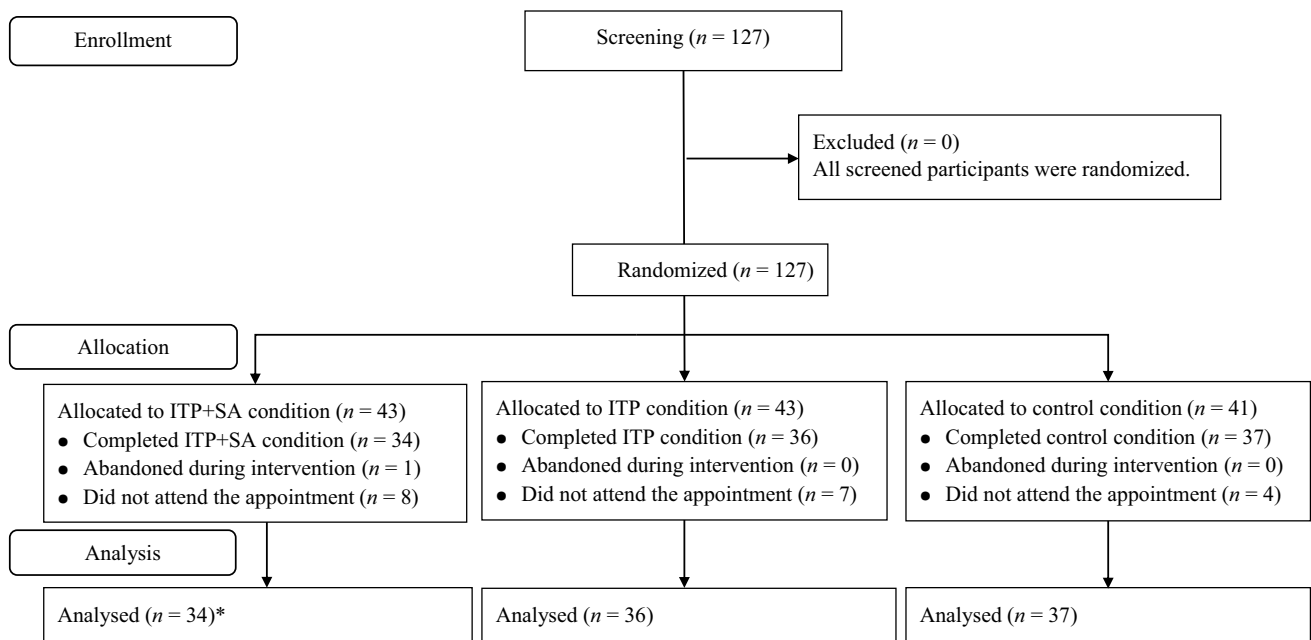
We conducted a blind randomized controlled trial with two different interventions (ITP+SA, ITP) and a CC. *A priori* power analysis (G\* Power) indicated that a total sample of ~110 participants was required for a small effect size (0.25), with alpha  $\alpha = .05$  and power = 80%. The final sample consisted of 107 first-year university students (mean age = 18.49, *SD* = 1.17; 80.2% female). The flow chart is displayed in Figure 1. The participants provided written informed consent, and the study was approved by the Ethics Committee of the University of University of Deusto.

## Measures

### Heart rate, RSA, and skin conductance level

Electrocardiograms (ECGs) to measure HR and RSA and Electrodermal Activity to measure SCL were recorded using the BioPac M150 system—which have been used for reference in the validation of other systems (Ragot et al., 2018)—at a sampling rate of 1000 Hz and AcqKnowledge® 4.0. We used lead II—with the negative electrode on the right clavicle and the positive one on the last left rib—with disposable foam electrodes after rubbing the skin with cotton and skin preparation gel for ECG. When measuring stress levels, the use of lead II is more accurate than alternative methods of electrode placement (Pourmohammadi & Maleki, 2020). Following the standards for electrodermal measurements (Braithwaite et al., 2012), SCL was recorded with electrodermal electrodes using isotonic electrode paste; electrodes were placed on distant phalanges of the ring and index fingers.

Prior to preprocessing with AcqKnowledge® 4.0 (BIOPAC Systems Inc), all data were visually screened for artifacts. For RSA, we used the HF-HRV (Fast-Fourier-Transformation, .15–.40 Hz), which is an established measure for evaluating PNS activity (Verkuil et al., 2016). SCL was estimated using the default processing settings in AcqKnowledge® 4.0. HR, SCL, and RSA were obtained in five-minute sequences under the following standard



**Fig. 1** Consolidated Standards of Reporting Trial Guidelines (CONSORT) Flow Diagram. Note. \* For RSA, HR and SCL, one participant’s scores were dropped due to outlier values

conditions of the TSST: baseline, speech preparation, speech, math task, and recovery.

### Hormonal measures: cortisol

Saliva samples were taken at baseline and recovery (i.e., at the end of the session). Following standard procedures (e.g., Nicolson, 2008) for the analysis of salivary samples, the participants were instructed not to brush their teeth, consume a meal or drink (with the exception of water), and to avoid intense exercise for at least two hours before sample donation. They were instructed to spit 2 mL of saliva into a plastic cup, and samples were stored in a freezer at  $-25^{\circ}\text{C}$  until they were sent to the IMQ Laboratory. Once in the lab, the samples were assayed for cortisol (nmol/L) levels in duplicate determinations (Electrochemiluminescence immunoassay, ECLIA; Inder et al., 2012).

### Psychological measures: subjective mood, depression, and anxiety

Mood was measured with the Scale for Mood Assessment (Sanz, 2001) at baseline and recovery. This scale was designed for measuring transitory moods. Sixteen items (e.g., “I feel happy,” “I feel depressed”) require participants to answer on an 11-point scale from 0 (*nothing*) to 10 (*a lot*) in terms of how they feel at the moment. The scale provides subscales for negative mood (12 items) and positive mood (4 items). The  $\alpha$  values were .89 and .86 at baseline and .94 and .90 at recovery for negative and positive mood, respectively.

Depressive and social anxiety symptoms were measured through an online questionnaire prior to the experimental session (see procedure section). The Center for Epidemiologic Studies-Depression Scale (CES-D; (Radloff, 1977), a 20-item questionnaire, was used to assess depressive symptoms. Respondents rated on a four-point scale, ranging from 0 (*practically never*) to 3 (*almost all the time*), how often over the past month they had experienced depressive symptoms (e.g., “My appetite was poor”) ( $\alpha = .90$ ).

Social anxiety symptoms were assessed with the Social Anxiety Scale for Adolescents (SAS-A) (La Greca & Lopez, 1998), which consisted of 18 items (e.g., “I am ashamed to be surrounded by people I do not know”, “I worry about what others say about me”) rated on a five-point scale ranging from 1 (*not at all*) to 5 (*all the time*) ( $\alpha = .94$ ). The SAS-A has been previously used with good psychometric properties and factorial invariance according to age with a sample of 15–18-year-old individuals (La Greca et al., 2015).

## Interventions and control condition

### ITP+SA intervention

The ITP+SA intervention included two components: an SA activity and an ITP intervention. The SA component was aimed at activating a positive perception of the self to make adolescents feel motivated, diminish defensive processes, and enable a positive response to accept the ITP intervention messages (Falk et al., 2015; Good & Abraham, 2011). SA interventions can include different activities, such as completing value scales, writing essays about central values, or completing questionnaires about one’s kindness (Good & Abraham, 2011). In particular, the SA component of this intervention included a list of 12 values from which participants had to indicate the three they deemed most important. Then, the participants were asked to choose one of the values and write a short paragraph arguing why the value they had chosen was important to them and to the extent to which it influences their life.

The ITP component resembled the intervention developed by Miu and Yeager (2015) and was adapted to first-year university students. It consisted of three parts. In the first part, the participants read scientific studies indicating that people can change. Furthermore, they read other studies that provided evidence showing that thoughts and feelings control behaviors through brain pathways and that these brain pathways can change under certain circumstances. Next, the participants were instructed to write a brief paragraph explaining why the evidence shows that people can truly change. In the second part, the participants read three testimonies. The narratives described different experiences of rejection, loneliness, and/or embarrassment lived by first-year university students when they started college. All the testimonies included the message that young people can change the way they behave and learn from their own experiences. In the last part, the participants completed a self-persuasive writing exercise to share with future students. The assignment was to describe a time when the participant felt rejected or disappointed by another person at university. Then, they imagined that the same event had happened to another student and wrote one to three paragraphs to help the other student to understand that people can change and that the things happening to him or her might also change.

### ITP-only intervention

In this condition, only the ITP component (without the SA component) described above was presented. In order to keep the length and structure of both interventions similar, participants were asked to select the three values they considered least important from a list of 12 values before completing the ITP component. Then, they had to choose one of them

and write a short paragraph arguing why that value, although least important for them, may be important for other people.

### Control condition (CC)

The CC was designed to have a similar structure to the experimental interventions, including neutral reading and writing tasks. The participants were asked to read an article about the fire that occurred in the Notre Dame cathedral in Paris. Starting from this accident, the article focuses on reflecting on the problem of heritage conservation and analyzing the situation of other important cathedrals. After reading the article, the participants were asked to write a few lines evaluating the importance of the conservation of historical buildings.

### Procedure

First, approval was obtained from the ethics committee of the University of Deusto. The University of Deusto has a strict protocol regarding the conditions under which university students may be invited to participate in studies. Permission was then sought from the heads of the faculties in which participants were to be recruited. Once permission was obtained, research team members presented the study to first-year university students. The students were also given a sheet with information and a contact email address for those interested in participating. One hundred twenty-six students completed an initial online assessment questionnaire using Qualtrics®, which included sociodemographic information and measures of depression and social anxiety. Inclusion criteria included being a first-year student, having completed preliminary measures, and voluntary participation. Exclusion criteria included cardiovascular disease and/or use of medication affecting the central nervous system. Given the relevance of depression and social anxiety during stress tasks, these measures were used to balance the participants within the intervention and control groups. Specifically, a cluster analysis was conducted, resulting in a four-cluster solution according to the participants' levels of depression and social anxiety. One-third of the males in each cluster and one-third of the females in each cluster were randomly assigned to each of the conditions (i.e., ITP+SA, ITP, and CC). This allowed the three conditions to be balanced in gender, social anxiety, and depression scores. Then, the participants were contacted via email to arrange a lab visit, which lasted approximately 1.5 hrs. One hundred and seven students came to the lab and completed the experimental tasks. The participants were welcomed to the lab by a researcher, who explained the study goals and collected the informed consent. The informed consent explained that during the study the participants would encounter social stress while the psychophysiological measures and saliva samples

were taken. They were also told that the data would be protected and would not be associated with any variable that could identify them. Instead, a bar code was used to join the psychophysiological data with those obtained through the questionnaires. The participants were notified that they could leave the experiment at any time if they wished. Three of the members of the research team were university professors, so the sessions were organized in such a way that a researcher would never interact with a participant who was their student. In this way, we sought to guarantee the principle of participant autonomy.

After signing the informed consent, baseline assessments were conducted in the following order: (1) participants answered the self-reported mood scale, and (2) baseline psychophysiological measures were recorded for 5 minutes. Next, the participants completed the assigned intervention, which lasted around 30 minutes. After baseline and intervention, the TSST consisted of: (1) a 5-minute speech preparation phase, (2) a 5-minute free speech task about the participants' personal capabilities that made them a good candidate for their ideal job, and (3) a 5-minute math task that consisted of subtracting the number 13 sequentially from 1022. Both the speech and math tasks were done in front of two confederates (one woman and one man) who were blind to the intervention condition. That is, they were unaware of which experimental condition the participants belonged to. Psychophysiological measures were taken during the three phases (15 minutes). Finally, the participants completed post-experimental measures in the following order: (1) salivary sample collection, (2) self-report of mood, and (3) psychophysiological recording during a 5-minute recovery period after informing the participants that they had already finished the tasks and could relax and think of something nice. Afterwards, the participants were thanked, debriefed, and compensated with a 20€ shopping voucher. One female participant in the ITP-SA condition abandoned the study in the five-minute speech preparation phase because she did not feel comfortable in the situation. She was reassured by the investigators, who thanked her for her help and gave her the voucher. The study was registered at [ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT04786496) (NCT04786496).

### Statistical analysis

Data were checked for normality before the statistical procedures were applied. As the RSA, SCL, and cortisol parameters did not have a normal distribution, they were log-transformed. In addition, one outlier for RSA, SCL, and HR was dropped. Growth curve modelling was used to test whether the change in RSA, SCL, and HR during the TSST was influenced by the intervention. The MLR (Robust Maximum Likelihood) estimation method with MPLUS 8.6 (Muthén & Muthén, 1998-2021) was used. Data were

hierarchically structured, with dependent measures nested within individuals and intervention, level of depression and the intervention  $\times$  level of depression interaction terms included as level-2 predictors. The goodness of the model fit was evaluated with the comparative fit index (CFI), the Tucker–Lewis Index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMS). Generally, a good fit is indicated by CFI and TLI values of .90 or higher and RMSEA and SRMS values lower than .08 (Hu & Bentler, 1999; Little, 2013).

A visual examination of RSA data through the TSST displayed a decreasing tendency from baseline to the speech phase and an increasing tendency from the speech phase to the recovery phase. The tendency for HR and SCL was the inverse, with an increase from baseline to the speech phase and a decrease from the speech phase to the recovery phase. For each dependent variable, first, we estimated a piecewise linear model that included one slope to capture the change from baseline to the speech phase (Slope 1, codes: 0, 1, 2, 2, and 2) and a second slope to capture the change from the speech phase to the recovery phase (Slope 2, codes: 0, 0, 0, 1, and 2). This piecewise linear model displayed poor fit indices for all variables. Second, we estimated an unconditional piecewise model in which the factor loadings for the preparation phase in the slope 1 and for the arithmetic phase in the slope 2 were freely estimated. An unconditional model does not force the slope of change across the measurement occasions to be a strict linear function (Little, 2013).

Instead, the shapes of the growth curve over time were simply estimated as parameters of the model. The unconditional piecewise models displayed adequate fit indices for all variables. Finally, these unconditional piecewise models were compared with curvilinear models including both linear and quadratic slopes. The curvilinear models displayed a poor fit for all variables. Moreover, the curvilinear models, compared with the unconditional piecewise models, involved a decrease in CFI higher than .01, which indicates a worse fit (Cheung & Rensvold, 2002). Therefore, the unconditional piecewise models were used as base to examine the effects of the interventions. Fit indices and estimated codes are included in Table 1.

The intervention was modeled with two dummy variables that specified the effects of each intervention (i.e., ITP+SA and ITP) by contrasting their effects with those of the CC, which acted as the reference group. The interaction terms between the interventions and level of depressive symptoms were included as predictors. Following standard procedures, the level of depressive symptoms was transformed into z-scores to maximize interpretability. Sex was initially included as a predictor of the intercept; however, in models in which it was not significantly associated with the intercept, it was dropped from the model.

As measures of cortisol and mood were collected only at baseline and after the math phase, path analysis was used to examine whether the intervention, level of depression, and their interaction predicted changes in cortisol and mood

**Table 1** Fit Indices and Estimated Codes

	Fit indices	Estimated codes
<b>RSA</b>		
Piecewise linear model	$\chi^2(6, 106) = 35$ ; RMSEA = .216 (90%CI = .150; .287), $p < .011$ ; CFI = .823; TLI = .70; SRMR = .099	
Unconditional piecewise model	$\chi^2(4, 106) = 4.43$ ; RMSEA = .032 (90%CI = .00; .15), $p = .48$ ; CFI = .997; TLI = .993; SRMR = .026	S1: 0, 1.45, and 2 S2: 0, 0.19, and 2
Curvilinear model	$\chi^2(6, 106) = 14$ ; RMSEA = .116 (90%CI = .038; .193), $p = .07$ ; CFI = .949; TLI = .915; SRMR = .051	
<b>SCL</b>		
Piecewise linear model	$\chi^2(6, 106) = 85$ ; RMSEA = .353 (90%CI = .289; .422), $p < .001$ ; CFI = .861; TLI = .768; SRMR = .119	
Unconditional piecewise model	$\chi^2(4, 106) = 11$ ; RMSEA = .10 (90%CI = .012; .19), $p = .11$ ; CFI = .989; TLI = .978; SRMR = .040	S1: 0, 1.66, and 2 S2: 0, 0.39, and 2
Curvilinear model	$\chi^2(6, 106) = 29$ ; RMSEA = .19 (90%CI = .126; .264), $p = .07$ ; CFI = .959; TLI = .931; SRMR = .030	
<b>HR</b>		
Piecewise linear model	$\chi^2(6, 106) = 39$ ; RMSEA = .226 (90%CI = .161; .297), $p < .001$ ; CFI = .891; TLI = .818; SRMR = .165	
Unconditional piecewise model	$\chi^2(4, 106) = 7$ ; RMSEA = .009 (90%CI = .00; .19), $p = .48$ ; CFI = .988; TLI = .971; SRMR = .107	S1: 0, 1.28, and 2 S2: 0, 0.52, and 2
Curvilinear model	$\chi^2(6, 106) = 14$ ; RMSEA = .131 (90%CI = .059; .207), $p = .25$ ; CFI = .964; TLI = .939; SRMR = .10	

Note. S = Slope

measures. Data of this study have been deposited into APA's repository at <https://osf.io/vuedw>.

## Results

There were no differences between groups in depressive symptoms and sex. Descriptive statistics are included in Table 2. The frequencies of the selected values in the ITP and ITP+SA conditions were examined. In the ITP+SA condition, the most frequent values that were selected as important for oneself were relationships with friends or family (88.6%), living in the moment (51.4%), and sense of humor (42.9%). In the ITP condition, the most frequent values that were selected as less important for oneself were religious values (86.1%), being good at art (50%), politics (44.4%), and athletic ability (44.4%).

### Effects of the intervention on RSA, SCL, and HR

Table 3 displays the main parameters of the predictive models for RSA, SCL, and HR during the TSST. The fit indices were adequate for RSA [ $\chi^2_{(14, 106)} = 23$ ; RMSEA = .082 (90%CI = .008; .137),  $p = .17$ ; CFI = .961; TLI = .902; SRMR = .045], SCL [ $\chi^2_{(14, 106)} = 18$ ; RMSEA = .050 (90%CI = .00; .112),

$p = .45$ ; CFI = .996; TLI = .989; SRMR = .029], and HR [ $\chi^2_{(18, 106)} = 27$ ; RMSEA = .070 (90%CI = .00; .12),  $p = .25$ ; CFI = .979; TLI = .953; SRMR = .072]. For RSA, slope 1 was negative (-0.15<sub>(.02)</sub>,  $p < .001$ ), whereas slope 2 was positive (0.22<sub>(0.02)</sub>,  $p < .001$ ). For SCL, slope 1 was positive (0.17<sub>(.01)</sub>,  $p < .001$ ), whereas slope 2 was negative (-0.06<sub>(.007)</sub>,  $p < .001$ ). Similarly, for HR, slope 1 was positive (8.10<sub>(0.89)</sub>,  $p < .001$ ), whereas slope 2 was negative (-8.87<sub>(0.94)</sub>,  $p < .001$ ). Sex was not associated with the intercept and slopes of RSA and SCL, and therefore it was dropped from the model for these variables. Being female, however, was positively associated with higher HR at baseline ( $b = 7.90_{(2.82)}$ ,  $p = .005$ ).

Regarding the first hypothesis, the main effects of the experimental conditions, RSA decreased less in the ITP group than in the CC during the first part of the TSST (i.e., from baseline to the speech task): Slope 1 = -0.08<sub>(0.09)</sub> vs -0.21<sub>(0.09)</sub>. Slope 1 for the ITP+SA group was -0.17<sub>(0.09)</sub> and was not significantly different from the slope of the CC. There were no significant differences between groups in the intercept and slope 2 (i.e., from speech to recovery). Figure 2 displays the trajectory of RSA for the three groups (ITP+SA, ITP, and CC) in the total sample.

Higher depressive symptoms were associated with lower values of RSA at baseline and a lower decline of RSA from baseline to the speech phase (i.e., slope 1) and a

**Table 2** Means and SD for all the Variables

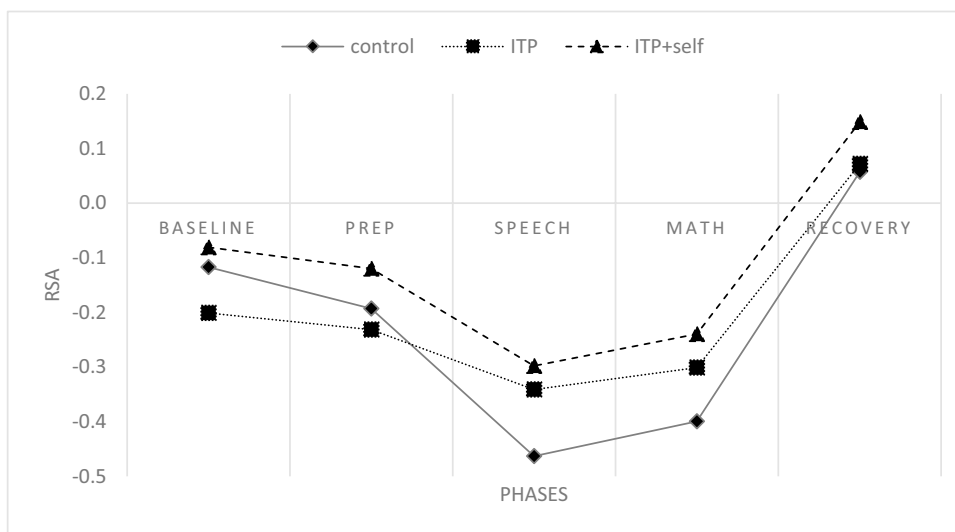
	ITP N = 36		ITP+SA N = 34*		Control N = 37	
	Mean	SD	Mean	SD	Mean	SD
<b>RSA</b>						
Baseline	0.95	0.61	1.11	0.45	1.10	0.62
Preparation	0.85	0.43	0.85	0.38	0.79	0.32
Speech	0.91	0.79	0.82	0.36	0.74	0.41
Math	0.80	0.42	0.88	0.40	0.75	0.36
Recovery	1.23	0.74	1.28	0.60	1.17	0.59
<b>HR</b>						
Baseline	77.44	14.16	72.30	11.26	75.50	11.55
Preparation	85.08	14.71	80.91	11.84	86.93	13.99
Speech	90.66	14.85	85.51	12.94	91.37	18.27
Math	86.58	12.59	81.35	10.61	86.99	16.13
Recovery	71.87	11.99	68.76	10.84	73.90	10.48
<b>SCL</b>						
Baseline	6.49	2.05	6.54	3.04	6.96	3.72
Preparation	8.63	2.24	8.21	3.00	9.01	4.23
Speech	8.84	2.13	8.69	2.85	9.36	4.15
Math	8.68	2.15	8.44	2.88	9.17	4.08
Recovery	8.20	2.43	7.64	2.97	8.35	3.83
<b>Cortisol</b>						
Baseline	0.35	0.23	0.34	0.25	0.40	0.34
Post-TSST	0.25	0.11	0.27	0.12	0.34	0.25

Note. \* For RSA, HR and SCL, one participant's scores were dropped due to outlier values.

**Table 3** Estimated Parameters for RSA, SCL, and HR Change During the TSST

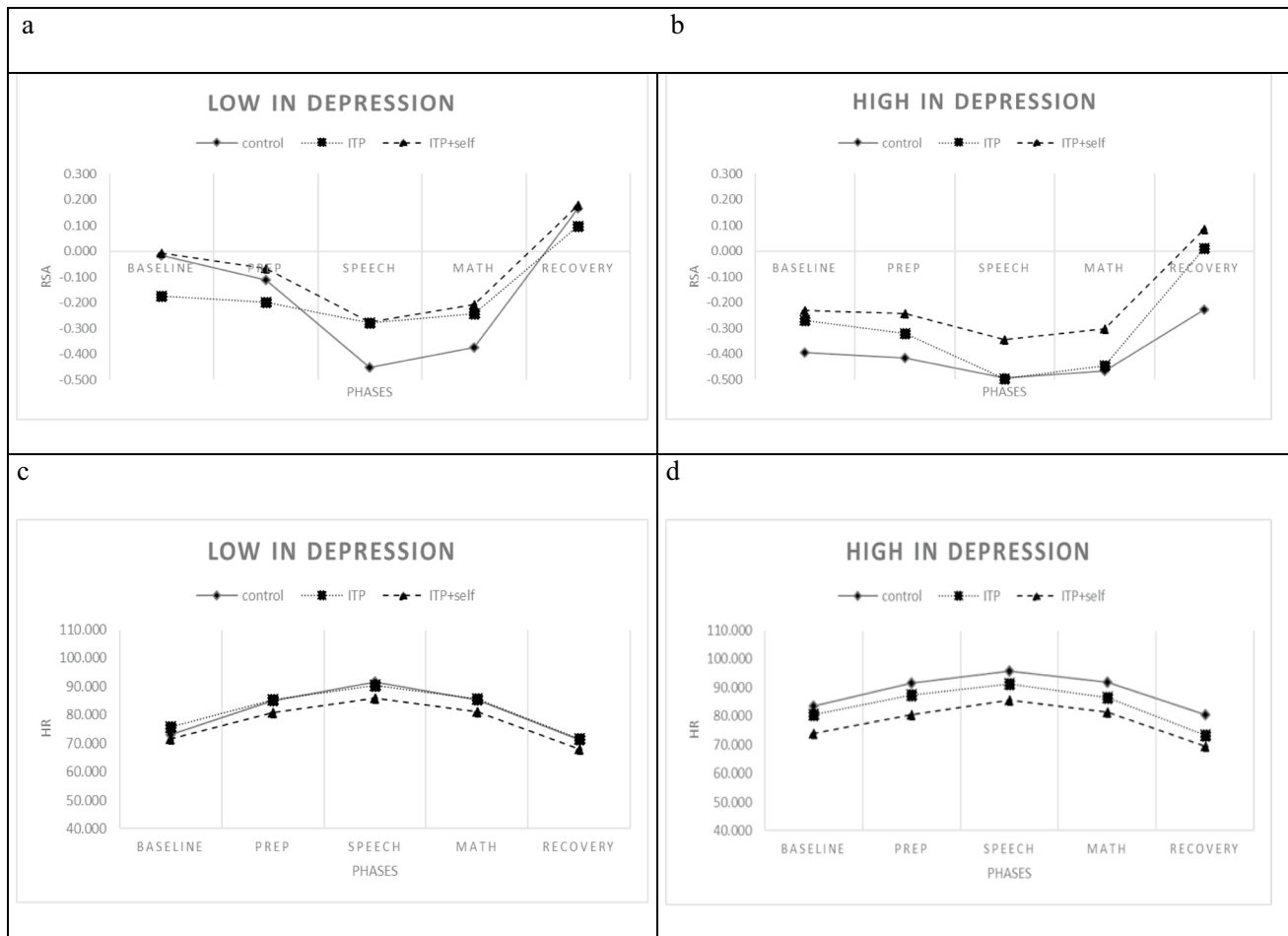
	RSA				SCL				HR			
	Estimate	SE	z	p	Estimate	SE	z	p	Estimate	SE	z	p
<b>Intercept</b>												
ITP+SA	0.04	0.10	0.43	.667	-0.03	0.12	-0.26	.797	-4.01	2.58	-1.56	.119
ITP	-0.15	0.11	-1.44	.151	0.02	0.10	0.23	.817	1.43	2.81	0.51	.612
Depression	-0.14	0.07	-1.96	.050	-0.26	0.08	-3.19	<.001	2.56	1.48	1.73	.084
ITP+SA x Depression	0.08	0.11	0.75	.453	0.30	0.13	2.39	.017	-2.50	2.31	-1.08	.278
ITP x Depression	0.12	0.11	1.05	.294	0.27	0.10	2.73	.006	-1.34	3.48	-0.38	.701
<b>Slope 1</b>												
ITP+SA	0.05	0.05	.99	.325	-0.00	0.04	-0.12	.902	-1.43	1.40	-1.02	.309
ITP	0.13	0.05	2.86	.004	-0.01	0.03	-0.43	.668	-1.46	1.32	-1.11	.269
Depression	0.08	0.03	2.26	.024	0.05	0.03	1.50	.133	-1.81	0.82	-2.20	.028
ITP+SA x Depression	-0.09	0.04	-2.06	.039	-0.02	0.04	-0.47	.639	1.20	1.15	1.04	.299
ITP x Depression	-0.10	0.05	-2.15	.032	-0.05	0.03	-1.54	.122	0.74	1.38	0.54	.591
<b>Slope 2</b>												
ITP+SA	-0.02	0.05	-0.38	.701	-0.01	0.02	-0.76	.450	0.42	1.35	0.31	.754
ITP	-0.04	0.05	-0.78	.433	0.02	0.02	1.36	.175	-0.43	1.26	-0.34	.732
Depression	-0.07	0.03	-2.38	.018	-0.00	0.01	-0.09	.931	1.59	0.85	1.87	.062
ITP+SA x Depression	0.08	0.04	1.84	.066	0.01	0.01	0.58	.566	-1.15	1.16	-1.00	.320
ITP x Depression	0.10	0.04	2.35	.019	0.01	0.01	0.77	.439	-1.53	1.12	-1.38	.169

**Fig. 2** RSA Trajectories for the Three Experimental Conditions in the Total Sample



lower increase from the speech phase to the recovery phase (i.e., slope 2). Moreover, the level of depressive symptoms moderated the effects of both the ITP+SA and the ITP in slope 1. Among participants who scored low-medium in depressive symptoms (percentile < 70), those receiving the ITP and the ITP+SA conditions displayed a lower decrease of RSA than CC: -0.06<sub>(0.09)</sub> for ITP, -0.17<sub>(.09)</sub> for ITP+SA, and -0.26<sub>(0.09)</sub> for CC. Among the participants high in depressive symptoms, there were no such differences in slope 1 depending on the condition.

Depressive symptoms also moderated the effect of the ITP intervention on slope 2. Among the participants who scored low-medium in depressive symptoms, slope 2 for RSA was higher in the CC than in ITP: 0.18<sub>(0.01)</sub> for the ITP group, 0.24<sub>(0.01)</sub> for the ITP+SA group, and 0.30<sub>(0.01)</sub> for CC. Among the participants who scored high in depressive symptoms, slope 2 was statistically significantly higher in the ITP than in the CC: 0.24<sub>(0.001)</sub> for the ITP, 0.20<sub>(0.001)</sub> for the ITP+SA, and 0.14<sub>(0.001)</sub> for the CC. Post hoc analysis indicated no significant differences between the ITP and



**Figs 3 a-3d** Trajectories of RSA and HR in Participants With Low-medium and High Levels of Depressive Symptoms

ITP+SA conditions. Figures 3a–3b display the trajectories for participants with low-medium depressive symptoms (percentile < 70) and those with high depressive symptoms (percentile ≥ 70).

As shown in Table 3, there were no significant effects of the intervention on SCL and HR change. At baseline, however, depressive symptoms were negatively associated with SCL. Moreover, depressive symptoms were associated with a lower increase of HR during the first three phases of the TSST (slope 1). Among the participants who scored low-medium in depressive symptoms, slope 1 was higher than among participants who scored high in depressive symptoms: 5.70<sub>(2.37)</sub> vs 5.80<sub>(2.33)</sub> (Figures 3c–3d).

**Cortisol and mood changes**

Finally, a path analysis (Table 4) was conducted to examine whether the intervention, level of depressive symptoms, and their interaction predicted changes in cortisol, negative mood, and positive mood from baseline to post-TSST. Sex was included as a covariate. Fit indices were excellent,  $\chi^2$

(20, 106) = 17; RMSEA = .000 (90%CI = .000; .067),  $p < .011$ ; CFI = .999; TLI = .999; SRMR = .039. The ITP intervention predicted lower levels of cortisol after the TSST (Figure 4).

Level of depressive symptoms was positively cross-sectionally associated with negative mood ( $b = 1.04_{(.39)}$ ,  $p = .008$ ) and negatively with positive mood ( $b = -2.84_{(0.58)}$ ,  $p < .001$ ) at baseline. Higher depressive symptoms predicted lower positive mood at posttest.

**Discussion**

This randomized controlled trial examined the effects of an ITP intervention (with and without a self-affirmation component) on responses to social stress in young adults. While we could demonstrate an effect of the ITP intervention, its combination with SA did not appear to improve the findings further. Importantly, psychophysiological sensitivity to the intervention was demonstrated for PNS and HPA axis parameters. Finally, the findings indicated that high levels of depressive symptoms predict flattened stress responses

**Table 4** Results of Path Analysis for Cortisol, Negative Mood, and Positive Mood

	Posttest-Cortisol				Posttest-Negative mood				Posttest-Positive mood			
	$\beta$	SE	z-score	<i>p</i>	$\beta$	SE	z-score	<i>p</i>	<i>B</i>	SE	z-score	<i>p</i>
<b>Depression as moderator</b>												
Baseline level	0.60	0.06	9.86	<.001	0.86	0.10	8.93	<.001	0.96	0.09	12.30	<.001
ITP+ SA	-0.05	0.08	-0.63	.528	0.48	1.12	0.43	.671	-0.41	1.51	-0.27	.786
ITP	-0.18	0.08	-2.37	.018	-0.15	1.07	-0.14	.887	1.69	1.37	1.24	.216
Depressive symptoms	-0.08	0.05	-1.51	.133	1.34	0.73	1.84	.065	-1.49	0.66	-2.26	.024
ITP+ SA x Depressive symptoms	0.06	0.07	0.91	.362	-0.79	1.06	-0.75	.455	0.79	1.08	0.73	.465
ITP x Depressive symptoms	0.13	0.07	1.71	.090	-0.87	1.08	-0.81	.420	0.17	0.94	0.18	.860

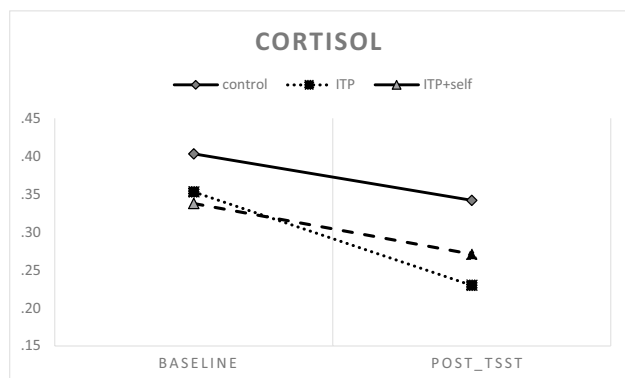
at the cardiovascular level and reduced the benefits of the interventions used.

Much research has linked depression with a dysregulated stress response (Lucas-Thompson et al., 2018). Simultaneously, research suggests that ITP interventions may protect against the development of depressive symptoms (Miu & Yeager, 2015) and that the beneficial effects of the intervention could be explained by better regulation of the psychophysiological and hormonal stress response (Yeager et al., 2016). The present study tested this hypothesis by examining the utility of ITP in young adults who are in the process of adapting to a novel environment (university) in their transition to adulthood. Indeed, a main effect of the ITP intervention on RSA indicated a protective role of ITP during the first phases (i.e., from baseline to speech) of the TSST because recipients of the intervention displayed a lower decline in vagal activation than those in the control group. Contrary to our hypothesis, however, ITP+SA did not show any main effect above the CC. Consistent with the RSA results, the ITP intervention, but not the ITP+SA intervention, also predicted a higher decrease in cortisol levels after exposure to social stress during recovery.

Prior findings have indicated the efficacy of SA interventions to buffer stress responses (Gregg et al., 2014; Sherman et al., 2009). Until further evidence is available, a tentative

explanation for our negative finding for the ITP+SA condition is that the task we included in the SA component could have made participants more aware of their vision of themselves, and, in some cases, this would harm them during stressful tasks, which involved speaking well of themselves and performing their best on a math test. Namely, in the speech task, participants had to argue why they were good for their ideal job position. It is possible that the values that were more frequently selected in the ITP+SA condition (e.g., living in the moment, relationships with friends or family, and sense of humor) were not relevant to the job position selected during the speech. In fact, values such as being smart or getting good grades, which may be more relevant to the type of job positions mentioned during the speech, were selected by very few participants. On the other hand, the values selected as least important for oneself in the ITP condition were probably not relevant for these positions (e.g., being good at art, religious values), and therefore indicating that these values were not very relevant in and of themselves did not affect their stress response during their speech.

Notably, the distribution of depressive symptoms was large in our cohort, which enabled us to examine their moderating influence on the interventions. For participants with low-medium levels of depressive symptoms, both interventions (ITP and ITP+SA) were beneficial, as they reduced RSA suppression during social stress. In contrast, among participants with high levels of depressive symptoms no such effect was present, suggesting that these participants may not be sensitive to ITP interventions. Relatedly, the level of depression also moderated the effect of both interventions during the recovery of vagal activation (i.e., during the second part of the TSST). However, participants with low-medium levels of depressive symptoms showed a greater increase in vagal activation in the CC than in the interventions. This effect could be explained by the preceding greater decline (i.e., greater RSA suppression during CC) in the first part of the TSST. As a result, greater RSA suppression would also imply greater space for the recovery of basal levels.

**Fig. 4** Change in Cortisol Levels From Baseline to Recovery

Depressive symptoms also influenced the trajectories of RSA and HR during the TSST *per se*. Specifically, participants with high levels of depressive symptoms reacted with lower RSA suppression and a lower HR increase during exposure to social stress and a lower RSA increase and HR decrease during recovery. Recently, Brugnera et al. (2019) also documented blunted heart-rate reactivity to a math task in healthy participants with high depressive symptoms. Such findings are consistent with the idea that hypo-reactivity during stress is a hallmark of depression (Schiweck et al., 2019). Finally, the level of depressive symptoms was cross-sectionally associated with more negative mood and less positive mood at baseline and predicted a decrease in positive mood after exposure to social stress. Our results indicate that participants with high levels of depressive symptoms, although less reactive at the cardiovascular level, react with a worsening of mood when exposed to social stress. Future work could examine which type of ITP interventions might be suitable for individuals with higher depressive symptoms.

### Limitations and strengths

First, although participant's sex was entered as a covariate, because ~80% of the sample was female, generalization of the efficacy of the intervention across genders is difficult, even if no effect of the nuisance variable occurred. Moreover, most of the participants were students of Psychology and Physical Activity and Sport Sciences, and future research should replicate findings with more diverse samples. Second, methodologically, an interesting question is why the intervention only influenced RSA but not HR or SCL. Few studies using the TSST have tested the effects of interventions on these physiological parameters. In one study (Pace-Schott et al., 2018), taking a nap after exposure therapy was capable of changing SCL. However, in another study assessing the influence of a psychological intervention, SCL did not change whereas HRV did (De Witte et al., 2017), suggesting that SCL may not be that sensitive to interventions. In line with good practice standards and transparency, such negative findings should be reported and may be useful to decide on the most promising psychophysiological measures for future work. Third, although the effects of the ITP+SA intervention have been evaluated on other behaviors (e.g., aggressive behaviors) at follow-ups of up to three months (Calvete et al., 2020), and the effects of the ITP alone intervention have been tested at nine-month and one-year follow-ups on depression and cortisol, showing stability of the results (e.g., Calvete et al., 2019; Miu & Yeager, 2015), the current study did not include a follow-up to examine whether the participants' psychophysiological stress response patterns remain stable over time. Four, we did not examine mediational mechanisms to explain the effects of the interventions. However, previous research has

found that ITP interventions change beliefs about the malleability of personality traits (e.g., Miu & Yeager, 2015), and this could thus be a potential mediational mechanism to explain changes in stress response patterns. Finally, future research should examine the conjoint effects of the combination of the ITP intervention with other approaches that have been found to be effective to improve stress responses, such as the stress reappraisal intervention (Jamieson et al., 2018). Interestingly, Crum et al. (2020) have proposed a stress optimization approach, which integrates theory and research on stress mindset and stress reappraisal interventions. This promising approach could be extended to include personality mindsets given that the results of the current and other previous studies suggest that personality mindsets interventions can improve stress reactivity (Calvete et al., 2019; Yeager et al., 2016).

Despite the limitations, the study has multiple strengths, including the use of an RCT design to study the effects of two different wise interventions in several psychophysiological stress markers. Moreover, the transition to college is an optimal time to test the ITP intervention used in this study, given that it includes scenarios related to adaptation to college life. University students often experience high levels of stress when making this transition (Wallace et al., 2017), and, according to Walton and Wilson (2018), it is important to identify times and contexts in which change is more possible than others (e.g., during transitions) to make wise interventions more effective.

### Conclusions

This study demonstrated that a one-session ITP intervention can reduce the psychophysiological and hormonal responses elicited by a social stressor in the lab. The results are therefore promising, given that ITP is a short and low-cost intervention that can be easily implemented. Benefits of these type of interventions include that are low-cost and accessible, and able to circumvent stigma (Osborn, Wasil, et al., 2020). However, the findings suggest that the intervention may be most beneficial when directed at participants with low or medium levels of depressive symptoms.

**Acknowledgements** The authors thank Juan Faura, Ainhoa Juaristi, Lys Vélez, and Aintzane Bidaurre for their help during the experiment.

**Availability of data and material** The protocol of the study has been registered at [ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT04786496) (NCT04786496). With the aim of maximize transparency, data of this study have been deposited into APA's repository at <https://osf.io/vuedw>.

**Funding information** Open Access funding provided thanks to the CRUE-CSIC agreement with Springer Nature. The research was supported by a grant from the Ministry of Economy and Competitiveness

(Spanish Government, Ref. PSI2015-68426-R) and from the Basque Country (Ref. IT982-16 and Ref. PI2016\_1\_0023).

## Declarations

**Conflicts of interest/Competing interests** None.

**Code availability** Not applicable

**Ethics approval** The procedures of this study have been approved by the institutional research committee of the University of Deusto and have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

**Consent to participate** Informed consent was required to the participants.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References

- Bauerly, K. R., Jones, R. M., & Miller, C. (2019). Effects of social stress on autonomic, behavioral, and acoustic parameters in adults who stutter. *Journal of Speech, Language, and Hearing Research, 62*(7), 2185–2202. [https://doi.org/10.1044/2019\\_JSLHR-S-18-0241](https://doi.org/10.1044/2019_JSLHR-S-18-0241)
- Braithwaite, J. J. J., Derrick, D., Watson, G., Jones, R., Rowe, M., Watson, D., Robert, J., & Mickey, R. (2012). Publication recommendations for electrodermal measurements. *Psychophysiology, 49*(8), 1017–1034. <https://doi.org/10.1111/j.1469-8986.2012.01384.x>
- Bower, P., Kontopantelis, E., Sutton, A., Kendrick, T., Richards, D. A., Gilbody, S., Knowles, S., Cuijpers, P., Andersson, G., Christensen, H., Meyer, B., Huibers, M., Smit, F., Van Straten, A., Warmerdam, L., Barkham, M., Bilich, L., Lovell, K., & Liu, E. T. H. (2013). Influence of initial severity of depression on effectiveness of low intensity interventions: Meta-analysis of individual patient data. *BMJ (Online)*. <https://doi.org/10.1136/bmj.f540>
- Brugnera, A., Zarbo, C., Tarvainen, M. P., Carlucci, S., Tasca, G. A., Adorni, R., Auteri, A., & Compare, A. (2019). Higher levels of depressive symptoms are associated with increased resting-state heart rate variability and blunted reactivity to a laboratory stress task among healthy adults. *Applied Psychophysiology Biofeedback, 44*(3), 221–234. <https://doi.org/10.1007/s10484-019-09437-z>
- Calvete, E., Cortazar, N., Fernández-González, L., Echezarraga, A., Beranuy, M., León, A., González-Cabrera, J., & Orue, I. (2020). Effects of a brief preventive intervention in cyberbullying and grooming in adolescents. *Psychosocial Intervention, 30*(2), 75–84. <https://doi.org/10.5093/pi2020a22>
- Calvete, E., Fernández-González, L., Orue, I., Echezarraga, A., Royuela-Colomer, E., Cortazar, N., Muga, J., Longa, M., & Yeager, D. S. (2019). The effect of an intervention teaching adolescents that people can change on depressive symptoms, cognitive schemas, and hypothalamic-pituitary-adrenal axis hormones. *Journal of Abnormal Child Psychology, 47*(9), 1533–1546. <https://doi.org/10.1007/s10802-019-00538-1>
- Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling, 9*(2), 233–255. [https://doi.org/10.1207/S15328007SEM0902\\_5](https://doi.org/10.1207/S15328007SEM0902_5)
- Cohen, G. L., & Sherman, D. K. (2014). The psychology of change: Self-affirmation and social psychological intervention. *Annual Review of Psychology, 65*(1), 333–371. <https://doi.org/10.1146/annurev-psych-010213-115137>
- Crum, A. J., Jamieson, J. P., & Akinola, M. (2020). Optimizing stress: An integrated intervention for regulating stress responses. *Emotion, 20*(1), 120–125. <https://doi.org/10.1037/emo0000670>
- Crum, A. J., Salovey, P., & Achor, S. (2013). Rethinking stress: The role of mindsets in determining the stress response. *Journal of Personality and Social Psychology, 104*(4), 716–733. <https://doi.org/10.1037/a0031201>
- De Witte, N. A. J., Sütterlin, S., Braet, C., & Mueller, S. C. (2017). Psychophysiological correlates of emotion regulation training in adolescent anxiety: Evidence from the novel PIER task. *Journal of Affective Disorders, 214*, 89–96. <https://doi.org/10.1016/j.jad.2017.03.012>
- Falk, E. B., O'Donnell, M. B., Cascio, C. N., Tinney, F., Kang, Y., Lieberman, M. D., Taylor, S. E., An, L., Kenneth, R., & Strecher, V. J. (2015). Self-affirmation alters the brain's response to health messages and subsequent behavior change. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 112*, 1977–1982. <https://doi.org/10.1073/pnas.1500247112>
- Fiksdal, A., Hanlin, L., Kuras, Y., Gianferante, D., Chen, X., Thoma, M. V., & Rohleder, N. (2020). Associations between symptoms of depression and anxiety and cortisol responses to and recovery from acute stress. *HHS Public Access, 102*, 44–52. <https://doi.org/10.1016/j.psyneuen.2018.11.035>
- Goger, P., Rozenman, M., & Gonzalez, A. (2020). The association between current maternal psychological control, anxiety symptoms, and emotional regulatory processes in emerging adults. *Journal of Behavior Therapy and Experimental Psychiatry, 68*, 101563. <https://doi.org/10.1016/j.jbtep.2020.101563>
- Good, A., & Abraham, C. (2011). Can the effectiveness of health promotion campaigns be improved using self-efficacy and self-affirmation interventions? An analysis of sun protection messages. *Psychology and Health, 26*(7), 799–818. <https://doi.org/10.1080/08870446.2010.495157>
- Gregg, J. A., Namekata, M. S., Louie, W. A., & Chancellor-Freeland, C. (2014). Impact of values clarification on cortisol reactivity to an acute stressor. *Journal of Contextual Behavioral Science, 3*(4), 299–304. <https://doi.org/10.1016/j.jcbs.2014.08.002>
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. <https://doi.org/10.1080/10705519909540118>
- Inder, W. J., Dimeski, G., & Russell, A. (2012). Measurement of salivary cortisol in 2012 – Laboratory techniques and clinical indications. *Clinical Endocrinology, 77*(5), 645–651. <https://doi.org/10.1111/j.1365-2265.2012.04508.x>

- Jamieson, J. P., Crum, A. J., Goyer, J. P., Marotta, M. E., & Akinola, M. (2018). Optimizing stress responses with reappraisal and mindset interventions: An integrated model. *Anxiety, Stress, & Coping*, *31*(3), 245–261. <https://doi.org/10.1080/10615806.2018.1442615>
- Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The “Trier social stress test” - A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*(1-2), 76–81. <https://doi.org/10.1159/000119004>
- La Greca, A. M., & Lopez, N. (1998). Social anxiety among adolescents: Linkages with peer relations and friendships. *Journal of Abnormal Child Psychology*, *26*(2), 83–94. <https://doi.org/10.1023/A:1022684520514>
- La Greca, A. M., Ingles, C. J., Lai, B. S., & Marzo, J. C. (2015). Social anxiety scale for adolescents: Factorial invariance across gender and age in Hispanic American adolescents. *Assessment*, *22*(2), 224–232. <https://doi.org/10.1177/1073191114540749>
- Little, T. D. (2013). *Longitudinal structural equation modeling*. Guilford press.
- Lucas-Thompson, R. G., McKernan, C. J., & Henry, K. L. (2018). Unraveling current and future adolescent depressive symptoms: The role of stress reactivity across physiological systems. *Developmental Psychology*, *54*(9), 1650–1660. <https://doi.org/10.1037/dev0000530>
- Miu, A. S., & Yeager, D. S. (2015). Preventing symptoms of depression by teaching adolescents that people can change: Effects of a brief incremental theory of personality intervention at 9-month follow-up. *Clinical Psychological Science*, *3*(5), 726–743. <https://doi.org/10.1177/2167702614548317>
- Muthén, L. K., & Muthén, B. O. (1998–2021). *Mplus user's guide*. Author.
- Nicolson, N. A. (2008). Measurement of cortisol. In L. J. Luecken & L. C. Gallo (Eds.), *Handbook of physiological research methods in health psychology* (pp. 37–74). Sage Publications. <https://doi.org/10.4135/9781412976244.n3>
- Osborn, T. L., Wasil, A. R., Venturo-Conerly, K., Schleider, J. L., & Weisz, J. R. (2020b). Group intervention for adolescent anxiety and depression: Outcomes of a randomized trial with adolescents in Kenya. *Behavior Therapy*, *51*(4), 601–615. <https://doi.org/10.1016/j.beth.2019.09.005>
- Osborn, T. L., Rodriguez, M., Wasil, A. R., Venturo-Conerly, K. E., Gan, J., Alemu, R. G., Roe, E., Arango, G., & S., Otieno, B. H., Wasanga, C. M., Shingleton, R., & Weisz, J. R. (2020a). Single-Session digital intervention for adolescent depression, anxiety, and well-being: Outcomes of a randomized controlled trial with Kenyan adolescents. *Journal of Consulting and Clinical Psychology*, *88*(7), 657–668. <https://doi.org/10.1037/ccp0000505>
- Pace-Schott, E. F., Bottary, R. M., Kim, S. Y., Rosencrans, P. L., Vijayakumar, S., Orr, S. P., Lasko, N. B., Goetter, E. M., Baker, A. W., Bianchi, M. T., Gannon, K., Hoepfner, S. S., Hofmann, S. G., & Simon, N. M. (2018). Effects of post-exposure naps on exposure therapy for social anxiety. *Psychiatry Research*, *270*, 523–530. <https://doi.org/10.1016/j.psychres.2018.10.015>
- Pourmohammadi, S., & Maleki, A. (2020). Stress detection using ECG and EMG signals: A comprehensive study. *Computer Methods and Programs in Biomedicine*, *193*. <https://doi.org/10.1016/j.cmpb.2020.105482>
- Pulopulos, M. M., Baeken, C., & De Raedt, R. (2020). Cortisol response to stress: The role of expectancy and anticipatory stress regulation. *Hormones and Behavior*, *117*, 104587. <https://doi.org/10.1016/j.yhbeh.2019.104587>
- Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*(3), 385–401. <https://doi.org/10.1177/014662167700100306>
- Ragot, M., Martin, N., Em, S., Pallamin, N., & Diverrez, J. M. (2018). Emotion recognition using physiological signals: Laboratory vs. wearable sensors. *Advances in Intelligent Systems and Computing*, *608*, 15–22. [https://doi.org/10.1007/978-3-319-60639-2\\_2](https://doi.org/10.1007/978-3-319-60639-2_2)
- Sanz, F. J. (2001). Un instrumento para evaluar la eficacia de los procedimientos de inducción de estado de ánimo: la "Escala de Valoración del Estado de Ánimo" (EVEA) [An instrument for evaluating the effectiveness of mood induction procedures: The "Mood Rating Scale" (EVEA)]. *Análisis y Modificación de Conducta*, *27*(111), 71–110.
- Schiweck, C., Piette, D., Berckmans, D., Claes, S., & Vrieze, E. (2019). Heart rate and high frequency heart rate variability during stress as biomarker for clinical depression. A systematic review. *Psychological Medicine*, *49*(2), 200–211. <https://doi.org/10.1017/S0033291718001988>
- Schleider, J. L., & Weisz, J. R. (2017). Little treatments, promising effects? Meta-analysis of single-session interventions for youth psychiatric problems. *Journal of the American Academy of Child and Adolescent Psychiatry*, *56*(2), 107–115. <https://doi.org/10.1016/j.jaac.2016.11.007>
- Schleider, J., & Weisz, J. (2018). A single-session growth mindset intervention for adolescent anxiety and depression: 9-month outcomes of a randomized trial. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *59*(2), 160–170. <https://doi.org/10.1111/jcpp.12811>
- Sherman, D. K., Bunyan, D. P., Creswell, J. D., & Jaremka, L. M. (2009). Psychological vulnerability and stress: The effects of self-affirmation on sympathetic nervous system responses to naturalistic stressors. *Health Psychology*, *28*(5), 554–562. <https://doi.org/10.1037/a0014663>
- Steele, C. M. (1988). The psychology of self-affirmation: Sustaining the integrity of the self. *Advances in Experimental Social Psychology*, *21*, 261–302. [https://doi.org/10.1016/S0065-2601\(08\)60229-4](https://doi.org/10.1016/S0065-2601(08)60229-4)
- Stice, E., Shaw, H., & Marti, C. N. (2006). A meta-analytic review of obesity prevention programs for children and adolescents: The skinny on interventions that work. *Psychological Bulletin*, *132*(5), 667–691. <https://doi.org/10.1037/0033-2909.132.5.667>
- Sung, G., Park, Y., Choi, T. K., & Park, S. W. (2020). Implicit theories and depression in clinical and non-clinical samples: The mediating role of experiential avoidance. *Current Psychology*, *39*(1), 68–73. <https://doi.org/10.1007/s12144-017-9736-z>
- Verkuil, B., Brosschot, J. F., Tollenaar, M. S., Lane, R. D., & Thayer, J. F. (2016). Prolonged non-metabolic heart rate variability reduction as a physiological marker of psychological stress in daily life. *Annals of Behavioral Medicine*, *50*(5), 704–714. <https://doi.org/10.1007/s12160-016-9795-7>
- Wallace, D. D., Boynton, M. H., & Lytle, L. A. (2017). Multilevel analysis exploring the links between stress, depression, and sleep problems among two-year college students. *Journal of American College Health*, *65*(3), 187–196. <https://doi.org/10.1080/07448481.2016.1269111>
- Walton, G. M., & Wilson, T. D. (2018). Wise interventions: Psychological remedies for social and personal problems. *Psychological Review*, *125*(5), 617–655. <https://doi.org/10.1037/rev0000115>
- Yeager, D. S., Dahl, R. E., & Dweck, C. S. (2018). Why interventions to influence adolescent behavior often fail but could succeed. *Perspectives on Psychological Science*, *13*(1), 101–122. <https://doi.org/10.1177/1745691617722620>

- Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., Tipton, E., Schneider, B., Hulleman, C. S., Hinojosa, C. P., Paunesku, D., Romero, C., Flint, K., Roberts, A., Trott, J., Iachan, R., Buontempo, J., Yang, S. M., Carvalho, C. M., et al. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature*, *573*(7774), 364–369. <https://doi.org/10.1038/s41586-019-1466-y>
- Yeager, D. S., Lee, H. Y., & Jamieson, J. P. (2016). How to improve adolescent stress responses: Insights from integrating implicit theories of personality and biopsychosocial models. *Psychological Science*, *27*(8), 1078–1091. <https://doi.org/10.1177/0956797616649604>
- Yeager, D. S., Trzesniewski, K. H., & Dweck, C. S. (2013). An implicit theories of personality intervention reduces adolescent aggression in response to victimization and exclusion. *Child Development*, *84*(3), 970–988. <https://doi.org/10.1111/cdev.12003>

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.