Current Psychology (2024) 43:25796–25808
https://doi.org/10.1007/s12144-024-06208-w

Beyond for-better-and-for-worse: expanding environmental sensitivity into a post-traumatic growth perspective

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Accepted: 28 May 2024 / Published online: 2 July 2024

Abstract
People differ in their responses to experiences with some showing a heightened Environmental Sensitivity (ES) for better and for worse. Highly sensitive people tend to get easily overwhelmed in adverse conditions but also to flourish in enriched environments. Yet, no studies have investigated whether people with a heightened ES may experience a positive outcome as well, in terms of Post-traumatic Growth (PTG), when a traumatic event occurs. This study provided a first empirical evidence regarding the relationship between ES and PTG on a general population of 2387 adults (age range: 18-88yy) surveyed online during the first Covid-19 lockdown. Correlations showed that ES was positively associated with PTG, though with a small effect size. Interaction effects from regression analyses provided evidence that the ES-PTG association was stronger when the individuals experienced anxiety to some extent, and not too much depression. To conclude, findings suggested highly sensitive people as not only more susceptible to adversities, but also more open to experience a growth when faced with challenging events. Identifying potential paths of growth in individuals who are more prone to negative feelings can have important implications for clinical practice as well as for theory by broadening our understanding of the concept of environmental sensitivity.

Keywords Sensory processing sensitivity · Post-traumatic growth · Highly sensitive people · Environmental sensitivity · Traumatic event · Spirituality · Anxiety · Depression · Covid-19

Introduction

Several concepts and theories have been independently proposed to explain how individual differ in their sensitivity to environmental exposures in a for-better-and-for-worse manner (Aron & Aron, 1997; Belsky et al., 2007; Belsky & Pluess, 2009; Boyce & Ellis, 2005). Such individual differences are more broadly captured by the concept of Environmental Sensitivity (ES; Pluess, 2015), which refers both to an individual trait capturing differences in sensitivity to environmental stimuli and to a meta-framework summarising existing theories on the individual – environment interplay including Differential Susceptibility (Belsky et al., 2007; Belsy & Pluess, 2009), Biological Sensitivity to Context (Boyce & Ellis, 2005), and Sensory Processing Sensitivity (Aron & Aron, 1997). Empirical evidence and theoretical reasoning suggest that in particular some people, a significant minority of the general population show higher levels of ES and tend to respond more negatively to adverse exposures but also more positively to nurturing and highly supportive environments (for reviews, see Greven et al., 2019; Obradović & Boyce, 2009; Pluess & Belsky, 2010; Slagt et al., 2016). Such environmentally highly sensitive or *orchid* individuals (see the floral metaphor as reported in Ellis & Boyce, 2011) show an increased sensitivity to environmental stimuli "for better and for worse" (Belsky & Pluess, 2009), and make up a sizeable minority, around 30%, of the general population. Low-sensitive people (also referred as *dandelions*, 29% of the general population)

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are more resilient to adversities but also less responsive to enriched environments, due to their low environmental sensitivity. Across this continuum from low to high, most individuals, also known as *tulips* (40% of the general population), have medium levels of sensitivity to environmental stimuli, higher than dandelions but not as much as orchids (Lionetti et al., 2018). Markers of an Environmental Sensitivity (ES; Pluess, 2015) have been identified at different level of analysis, including genes (Keers et al., 2016) and a physiological level (Boyce & Ellis, 2005). At a phenotypical, psychological level, a marker that captures such individual differences in ES to stimuli is the biologically based individual trait of Sensory Processing Sensitivity (SPS; Aron & Aron, 1997; Aron et al., 2012), which can be measured with the Highly Sensitive Person (HSP) scale (Aron & Aron, 1997; Pluess et al., 2023).

Environmental sensitivity for better and for worse

Environmental sensitivity has contributed to increase our knowledge on how individuals differ in the way they respond to a variety of contexts, including the family environment (e.g., see Slagt et al., 2018), prevention and intervention programs (de Villiers et al., 2018; Ceccon et al., 2023), job environments (Vieregge et al., 2023) and media exposures (Rubaltelli et al., 2018), informing psychology across different fields. In both child and adult samples, studies show that heightened ES is manifested in deeper processing of environmental information, stronger physiological and emotional reactivity, and in greater awareness and appreciation of subtle details (Aron et al., 2012; Greven et al., 2019; Lionetti et al., 2019a). Likely because of this deeper processing of stimuli, high ES has been found to confer increased vulnerability to low-quality or stress-eliciting environments with a higher risk for dysfunctional outcomes (for worse), but also a higher reactivity to positive environments, allowing highly sensitive individuals to flourish disproportionately when positive circumstances allow for that (for better). For example, when exposed to negative parenting behaviours (i.e., negative control, intrusiveness, overprotection, harsh discipline, physical punishment, rejection, hostility, and parenting stress), children scoring high in ES develop more externalizing problems (Lionetti et al., 2019a; Slagt et al., 2018) and difficulties in regulating emotions (Sperati et al., 2022). Likewise, the absence of clear boundaries and rules characterizing a permissive parenting predicts internalizing symptoms (i.e., depression and rumination) during middle-childhood and pre-adolescence (Lionetti et al., 2019a, 2021). Similarly, increased ES in adults predicts greater levels of anxiety and depression as well as lower life satisfaction in the context of poor nurturing environments and unfavourable childhood experiences (Booth et al., 2015; Liss et al., 2005). Empirical studies also showed that highly sensitive adults are more impacted by the exposure to negative media pictures (Rubaltelli et al., 2018) and to work-related stress (Redfearn et al., 2020). On the other hand, highly sensitive children benefit more from positive parenting (Lionetti et al., 2019a; Li et al., 2021), and highly sensitive pre-adolescents and adolescents exceptionally benefit from psychological prevention programs (Ceccon et al., 2023; de Villiers et al., 2018; Nocentini et al., 2018; Pluess & Belsky, 2013; Pluess & Boniwell, 2015; Pluess et al., 2017). Similarly, highly sensitive employees are more responsive to positive job characteristics in terms of positive job attitudes (Vieregge et al., 2023).

A post-traumatic growth perspective

Yet, the above reviewed for-better-and-for-worse dichotomous conceptualization does not consider the phenomenon of post-traumatic growth (PTG), according to which a negative environmental experience does not necessarily predict maladjustment, but it might become an opportunity for individual growth as well (Tedeschi & Calhoun, 1996). In other words, the adversity itself may trigger resources and strengths that promote an in-depth and valuable change in the way the self and the world are perceived. Because of their deeper processing of stimuli, this can be potentially true for highly sensitive people as well.

Theories of PTG describe positive changes involving five distinct psychological domains: *New Possibilities* (i.e., positive evaluations of new life possibilities around), *Relationships with Others* (i.e., positive changes and the development of more meaningful relationships), *Personal Strength* (i.e., sense of self-efficacy and perceived strength in coping with future challenging events), *Spiritual Change* (i.e., a greater involvement in religious and existential questions), and *Life Appreciation* (i.e., appreciation of small life details that may have gone unnoticed before the traumatic experience) (Tedeschi & Calhoun, 1996). According to recent meta-analyses (Shakespeare-Finch & Lurie Beck, 2014; Long et al., 2021), changes across these domains in non-clinical populations are more likely to occur when the individual experiences a moderate – neither too low, nor too high – level of post-traumatic symptoms (i.e., moderate levels of stress and anxiety), and when they process stimuli and details characterizing the adverse event more deeply. A slightly different path emerged for depression: individuals who reported higher levels of depressive symptoms showed lower levels of PTG (Long et al., 2021; Tedeschi & Calhoun, 1996).

In the current paper, we propose that, due to their deeper cognitive processing and their heightened interest in, and attention to, philosophical questions (Aron, 2002), highly sensitive people may not only suffer more than others when

confronted with challenging events, but also potentially find more opportunities for growth when facing difficult situations that require re-processing of priorities and reflection on meaning and purpose. To date, this possibility has not been explored yet. The current study sought to address this gap by investigating, for the first time, the role of environmental sensitivity in post-traumatic growth. We will accomplish this aim by investigating ES and PTG in a large sample of a general population of adults recruited during a challenging event such as the first COVID-19 lockdown. Identifying a potential path of growth in individuals more prone to negative affect (see also meta-analytic findings, Lionetti, Pastore et al., 2019b) can have important implications for clinical practice (i.e., getting aware of strengths to make them flourish) as well as for theory by broadening our understanding of the concept of ES.

Overview of the current study

The current study has two aims. First, to explore the role of individual differences in ES in explaining PTG levels. Second, to investigate whether the individual levels of anxiety and depression moderated the association between ES and PTG. We considered the first lockdown of the COVID-19 pandemic as the collective traumatic event potentially generating protracted secondary stress (see Holman et al., 2022), hence allowing the study of PTG in the general population (Chen et al., 2021; Lau et al., 2021; Stallard et al., 2021; Vazquez et al., 2021).

Because of the deeper processing of environmental inputs that characterizes heightened sensitivity, we expected increased ES to predict greater PTG. However, considering that individuals with higher levels of ES tend to be overwhelmed under challenging conditions, we further hypothesized that anxiety and depression experienced during COVID-19, would play a moderating role. For example, in line with the notion that PTG correlates positively with anxiety and negatively with depression (Long et al., 2021) and considering that highly sensitive individuals tend to be overwhelmed by the exposure to negative events, we can expect ES to predict PTG only when individuals experienced anxiety to some extent, but not too much. At the same time, we can hypothesize depression as a risk factor decreasing the likelihood of experiencing a PTG for higher levels of ES.

Materials and methods

Participants and procedure

A large sample of a general population of $N = 2387$ Italian adults completed an online survey during the national lockdown in response to the first wave of the COVID-19 pandemic (March-May, 2020). Of these, $n = 172$ (7.2%) have been directly in contact with COVID-19 with either themselves or their relatives showing symptoms and needing care. The survey included measures of ES, PTG, and anxiety and depression. Data, limited to the assessment of ES, were previously used in a study investigating the structure of the measure in students and in the general population (Lionetti et al., 2024). Participants' mean age was 40 years (age range = 18–88 years, $SD = 12.5$), and 87.9% were female. The sample had the following educational levels: 0.13% primary school degree, 7.4% middle school degree, 43.6% high school degree, 14.7% bachelor degree, 21.7% master degree, and 12.6% post-graduate degree (either a poster master degree course or a PhD), in line with Italian census data (ISTAT, 2022). The sample was recruited from all Italian regions (twenty different regions in total) following a snowball procedure. Recruitment occurred mainly via social media platforms advertising the study in several groups to reach different populations, and through instant messaging spreading the survey via personal contacts. The initial groups were directly contacted by the research team and then were encouraged to share the link among personal contacts. Informed consent was obtained from all participants who were aware of the general aim of the survey (i.e., exploring the role of individual characteristics in the emotional experience during the early period of COVID-19). Data are openly available online at the following link: https://gitfront.io/r/user-8766068/E3ou69ToEQAm/Sensory-Processing-Sensitivity-And-Post-Traumatic-Growth/.

Measures

Environmental sensitivity

As a marker of ES, we considered the individual trait of Sensory Processing Sensitivity, assessed using the 12-item Highly Sensitive Person scale (HSP; Pluess et al., 2023), recently validated in an Italian population (Lionetti et al., 2024). The HSP-12 aims at capturing an increased appreciation of, and greater attention to subtleties (e.g., "Do you seem to be aware of subtleties in your environment?"), a strong feeling of getting overwhelmed as well as a low sensory threshold (e.g., "Do changes in your life shake you up?"; "Are you easily overwhelmed by things like bright lights, strong smells, coarse fabrics, or sirens close by?"). Each item is rated on a 7-point Likert scale ranging from 1 = Not at all to 7 = Extremely, with higher scores indicating higher levels of SPS. The measure provides a total score of general sensitivity. In the current sample, internal consistency of the total score was good (Cronbach's $\alpha = .79$) and in line with the original (Pluess et al., 2023) validation study.

Post-traumatic growth

We investigated PTG using the Italian version of the Post-traumatic Growth Inventory (PTGI; Tedeschi & Calhoun, 1996; Prati & Pietrantoni, 2014), which consists of 21 items rated on a 6-points Likert scale ranging from 0 = No change to 5 = Very important change. PTGI items assess the perceived positive changes arising from the traumatic event across five different psychological dimensions: (1) *New Possibilities*, i.e. identifying and pursuing new life path arising from the stressful event (e.g., "New opportunities are available which wouldn't have been otherwise."); (2) *Relations with Others*, referring to a potential greater involvement in meaningful interpersonal relationships (e.g., "I more clearly see that I can count on people in times of trouble"); (3) *Personal Power*, capturing a greater sense of self-efficacy and an increased perceived strength in coping future challenging events (e.g., "I know that I can handle difficulties"); (4) *Changes in Spirituality*, exploring the extent to which the individual experience a greater involvement in religious and existential issues (e.g., "I have stronger religious faith"), and (5) *Life Appreciation*, which includes noticing and appreciating subtle positive details of living (e.g., "I can better appreciate each day"). In the current sample, we found good internal consistency for all the PTG dimensions (α = .85 for New Possibilities; α = .89 for Relations with Others; α = .85 for Personal Power; α = .75 for Changes in Spirituality; α = .78 for Life Appreciation).

Anxiety and depression

We investigated perceived anxiety and depression using items from the Depression and Anxiety subscales of the Italian version of the Depression, Anxiety, and Stress Scale (DASS; Lovibond & Lovibond, 1995; Bottesi et al., 2015). The 14 items assess somatic and subjective feelings of anxiety and response to fear (e.g., "I found myself getting agitated") as well as depressive symptoms such as lack of incentive and dysphoria (e.g., "I couldn't seem to experience any positive feeling at all") rated on a 4-point Likert scale from 0 = Never to 3 = Always. In the current sample, we found acceptable levels of internal consistency for both anxiety and depression subscales (α = .80 and .88, respectively).

Data analysis

In preliminary analyses, we first explored the distribution of missing values and computed bivariate associations among all study variables to investigate how SPS, PTG, and anxiety and depression were associated with each other. We considered associations to be low when Pearson's *r* was around .10 or less, medium if *r* varied around.30, and large if *r* was higher than .50 (Cohen, 1988, 1992). Next, to explore the hypothesised effect of SPS on PTG, we ran a series of linear regression models considering SPS as predictor of each PTG dimension. Then, we added negative affect variables of anxiety and depression as moderators in the models to investigate whether SPS predicted PTG depending on levels of anxiety and depression. Parameters were estimated via a Bayesian approach, providing posterior distribution credible intervals that are more informative than traditional maximum likelihood estimation methods. Moreover, in case of null findings, the Bayesian estimation provides support for a lack of effect (Vandekerckhove et al., 2018). We adopted weakly informative default priors that do not strongly affect the posterior, but provide regularization to stabilize computation and avoid overfitting. To identify the best fitting model (main effect vs. interaction effect), we used two comparative indices: leave-one-out cross-validation information criterion (Loo IC), with lower values reflecting a better fit of the model to the data, and the model weight criterion, with higher values reflecting a stronger support for the model (Vehtari et al., 2017). After selecting the best fitting model, we calculated estimated parameters (represented by the median and its associated variability – MAD) and credible interval values (CI). If credible intervals do not contain zero, an effect can be reasonably supported or interpreted as meaningful. We finally followed-up interaction effects by adopting conditional interaction plots. All analyses were run using the rstanarm package (Goodrich et al., 2020) and ggplot2 package (Wickham, 2016) in statistical software R (R Core Team, 2020).

Results

Descriptive statistics and bivariate associations among variables

For handling missing, because their frequency and percentage in the total sample across all measures was very low ($n = 27$ items; .02%) and missing data were completely at random (as suggested by results from Little's MCAR test (i.e., $p = .72$), we adopted listwise deletion. All descriptive statistics and bivariate associations are shown in Table 1. Regarding the relationship between SPS and PTG, we found positive, but small associations between SPS and all PTG domains. In more detail, SPS showed a small association with New Possibilities ($r = .08$) and Personal Power ($r = .06$), and had a slightly stronger association with Relations with Others ($r = .10$), Changes in Spirituality ($r = .11$), and Life Appreciation ($r = .13$). SPS was positively and moderately associated with anxiety ($r = .32$) and depression

Table 1 Bivariate associations among HSP total score, PTG dimensions, anxiety, and depression ($N = 2382$)

	Mean (SD)	1	2	3	4	5	6	7	8	9	10
1 HSP (1 = Not at all – 7 = Extremely)	4.48 (.96)	—									
2 PTG-NP	1.71 (1.24)	.08	—								
3 PTG-RO	1.49 (1.19)	.10	.76	—							
4 PTG-PP	1.87 (1.38)	.06	.80	.70	—						
5 PTG-CS	.84 (1.22)	.11	.52	.55	.49	—					
6 PTG-LA	2.46 (1.30)	.13	.73	.66	.65	.45	—				
7 Anxiety	1.25 (1.34)	.32	.12	.15	.04	.12	.16	—			
8 Depression	1.80 (1.57)	.31	−.01	.04	−.06	.04	.05	.69	—		
9 Age	40.81 (12.48)	.03	−.14	−.11	−.09	.06	−.06	−.12	−.12	—	
10 Gender (1 = Male – 2 = Female)		.16	.09	.07	.09	.07	.13	.08	.06	.04	—

According to Cohen (1988, 1992): trivial associations: r lower than $r = .10$; moderate associations: $r = 25–45$; strong association: r higher than .50

HSP Highly Sensitive Person scale Total Score, *PTG-NP* New possibilities, *PTG-RO* Relations with others, *PTG-PP* Personal Power, *PTG-CS* Changes in Spirituality, *PTG-LA* Life Appreciation

($r = .31$), and slightly with female gender ($r = .16$), but not with age ($r = .03$). Finally, the associations between all PTG dimensions and anxiety were positive and small and varied from $r = .12$ to $r = .16$, except for Personal Power ($r = .04$), whereas the associations between PTG domains and depression were close to zero. Bivariate associations among PTG dimensions ranged between .50 for Spiritual Changes with other PTG dimensions to .80 for Personal Power with New Possibilities.

Sensory processing sensitivity predicting post-traumatic growth

Main effect models suggested SPS to be significantly and positively associated with the perception of positive changes in all PTG domains. More specifically, SPS was associated with Life Appreciation (median .18, MAD = .03, 90% CI .14, .23) and Changes in Spirituality (median = .14, MAD = .03, 90% CI .10, .18) with an effect size of at least .10 or higher. For all other PTG dimensions, positive but slightly lower associations between SPS and PTG were found, varying from median .08 to .12: New Possibilities, median = .11, MAD = .03, 90% CI .06, .15; Relations with Others, median = .12, MAD = .03, 90% CI .08, .16; Personal Power, median = .08, MAD = .03, 90% CI .03, .13. Importantly, in no case SPS was negatively related to PTG, not even at the lower bound of the posterior distribution range.

Sensory processing sensitivity, anxiety and their interaction in predicting post-traumatic growth

We then tested if anxiety moderated the extent to which SPS predicted PTG. For three out of five PTG dimensions (i.e., New Possibilities, Personal Power, and Relations with Others), findings showed that the interaction model including SPS * anxiety outperformed the model with the main effects only (SPS + anxiety), with a comparable pattern of findings (see Table 2 for the results of model comparison). Estimated parameters of the interaction pattern for New Possibilities, Personal Power, and Relations with Others were all relevant, not including the zero in the CI, and comparable in terms of effect size. For the dimensions of Changes in Spirituality and Life Appreciation, the main effect model was supported as fitting the data significantly better over the other models considered, with a positive effect of both SPS and anxiety on Changes in Spirituality. All estimated parameters of the models selected to predict data best (see Table 2) are reported in Table 4.

To interpret interaction effects, we plotted simple slopes for low (below the first 25th quantile,) medium and high levels (above the forth – 75th – quantile) of anxiety (see Fig. 1). For high levels of anxiety, we found overall higher levels of PTG irrespective of SPS levels. In other words, individual differences in SPS did not predict PTG when anxiety was high. When anxiety was low, and to a lower extent, for medium anxiety levels, the higher SPS, the greater was PTG. In other words, while in a context of high levels of anxiety, PTG was relatively high irrespective of SPS levels, at low levels of anxiety, only higher levels of SPS allowed individuals to experience growth in response to the first COVID-19 lockdown.

Sensory processing sensitivity, depression and their interaction in predicting post-traumatic growth

Comparable to the analyses on anxiety, the interaction model SPS * Depression was supported as fitting the data significantly better than the main effect model (SPS + Depression) for four out of the five PTG domains, that is, for New Possibilities, Relations with Others, Personal Power, and Life Appreciation (see Table 3 for results of model comparison). Only for Changes in

Table 2 Comparison of regression models ($N = 2382$). Sensitivity and anxiety in predicting PTG dimensions

	New possibilities					Relations with others					Spirituality					Personal power					Life appreciation				
	R2	low	up	Looic	w	R2	low	up	Looic	w	R2	low	Up	Looic	w	R2	low	up	Looic	w	R2	low	up	Looic	w
Main	.017	.010	.024	7749	.31	.027	.019	.035	7528	.24	.021	.015	.030	**7658**	**1.0**	.004	.002	.008	8295	.21	.034	.026	.044	**7961**	**.94**
Interaction	.020	.013	.027	**7747**	**.69**	.029	.021	.038	**7525**	**.77**	.022	.015	.030	7660	.0	.008	.004	.012	**8290**	**.79**	.035	.026	.045	7962	.06

The main effect models include sensitivity and anxiety as predictors on PTG facets. The interaction effect models include anxiety in interaction with sensitivity in predicting PTG facets

Looic leave-one-out cross-validation information criterion, *w* model weight

Spirituality, the main effect model was supported as fitting the data better than the interaction model with a positive effect on Changes in Spirituality of SPS only. All estimated parameters are reported in Table 4.

We followed up interaction effects by dividing the moderating variable of depression in low (below the first 25th quantile), medium, and high levels above the forth – 75th – quantile). The plot of interaction effects showed that irrespective of levels of depression, the higher SPS, the higher was PTG. Importantly, individuals high in SPS showed the highest levels of growth when depression was low. Conversely, for low levels of SPS, a PTG was more evident for higher levels of depression. Although data supported an interaction model over a main effect model for four out of five PTG domains (see Fig. 2), variability bars showed a moderate degree of overlap, suggesting that the difference in the extent to which SPS predicted PTG across the different depression levels were small.

Follow-up exploration

As the degree of contact with COVID-19 could influence the individual perception of the traumatic event and PTG as well, we exploratory ran a series of models including the degree of contact with COVID (1 = My relatives or me in direct contact with COVID-19 with the need of care, 0 = no contact) in interaction with anxiety and depression and SPS (i.e., we explored whether having been in contact with COVID-19 impacted on the extent to which SPS interacted with anxiety and depression in predicting PTG). Findings, reported in the supplementary material section, suggested that for both anxiety and depression results were overall stable and the best model selected did not change when including the contact with COVID-19 control variable, except for Life Appreciation where a main effect model appeared to be overall comparable to the two-way interaction model. In other words, models including the interaction with COVID-19 control variable, exploratory considered for investigating whether findings changed as a function of contact with COVID-19, did not fit data better than models including only ES, anxiety/depression and their interaction.

Discussion

Some individuals are characterised by a heightened sensitivity for better and for worse. Due to the deeper processing of environmental details as suggested by the individual trait of environmental sensitivity, highly sensitive people flourish and benefit more from opportunities when exposed to enriched environments, but they are also more prone to get overwhelmed when facing adverse conditions compared to

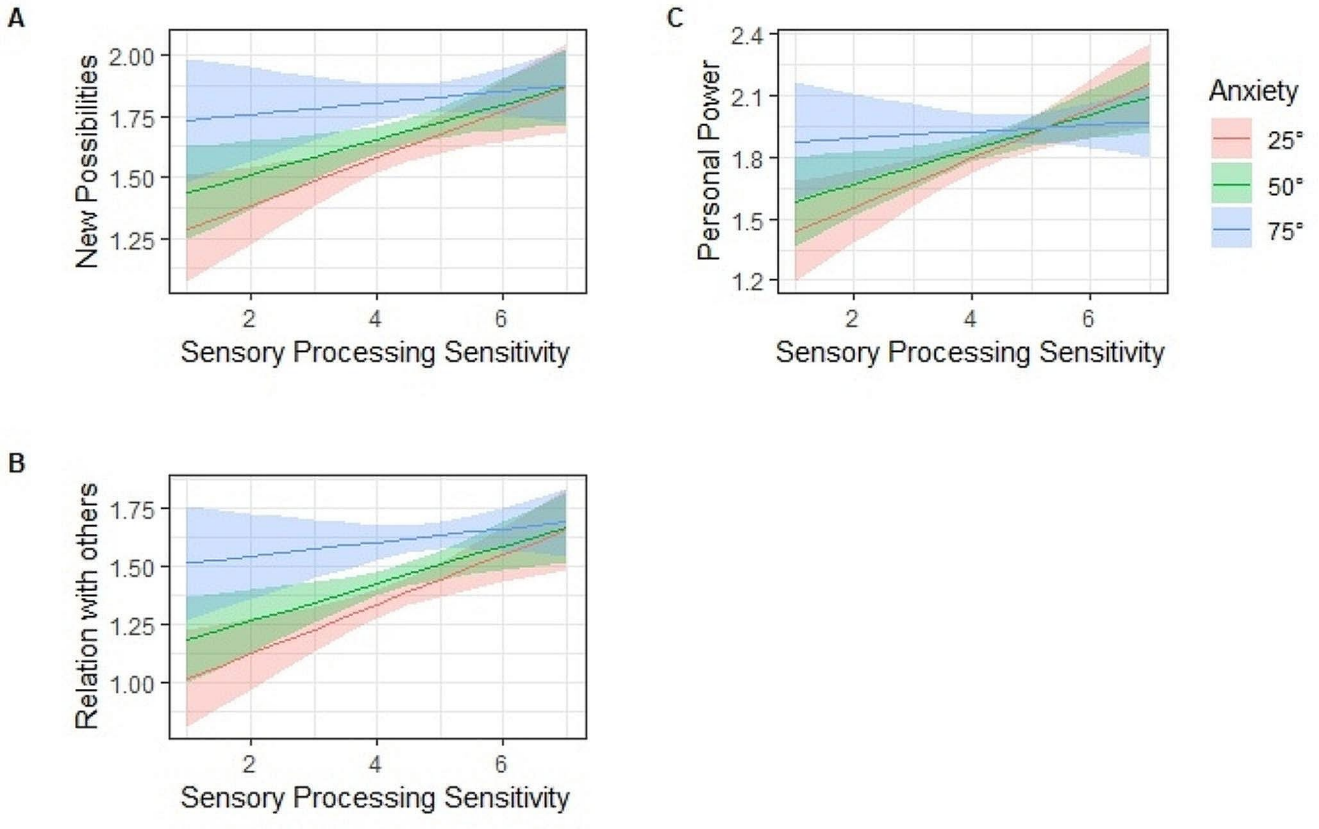

Fig. 1 SPS and Anxiety in predicting PTG domains. SPS and anxiety interaction in predicting New Possibilities (**A**), Relations with others (**B**), and Personal power (**C**) PTG domains. As reported in the result section, for Changes in Spirituality and Life appreciation, a main effect model was supported. The moderating variable of anxiety was divided in low (below the first 25th quantile), medium, and high levels (above the forth – 75th – quantile)

less-sensitive individuals (Greven et al., 2019; Obradović & Boyce, 2009; Pluess & Belsky, 2010; Slagt et al., 2016). To the best of our knowledge, no studies have investigated whether people high in sensitivity, as captured by the Sensory Processing Sensitivity trait (SPS; Aron & Aron, 1997) may experience a positive outcome as well, in terms of PTG, when a collective traumatic event occurs.

The current study aimed at addressing this issue by providing first empirical evidence regarding the positive relationship between SPS and PTG in a large sample of Italian adults surveyed online during the first national COVID-19 lockdown, considered as a potential collective traumatic event (Holman et al., 2022). Results from bivariate associations showed SPS to be positively and moderately associated with anxiety and depression, with highly sensitive individuals being more prone to experience negative internalizing feelings, although associations were small. This finding is coherent with previously reported associations between sensitivity and neuroticism, anxiety and depression in adult samples (Booth et al., 2015; Liss et al., 2005, and Lionetti, Pastore et al., 2019b for a meta-analysis). In other words, it seems that the association between SPS and anxiety and depression was not strictly related to the COVID-19 lockdown during which we collected the data. However, interestingly, multiple regressions showed SPS being positively related to all PTG dimensions we investigated as well, even though the degree of association was relatively small. Based on the hypothesis that the degree to which SPS predicts PTG depends also on the extent to which individuals experience the event as an actual source of distress (as captured by anxiety and depression), we explored interaction effects to see whether SPS differently predicted PTG as a function of the level of anxiety and depression experienced during the lockdown. SPS was not a predictor of PTG when anxiety was high. In other words, irrespective of sensitivity levels, all individuals experienced the highest levels of growth in a context of heightened anxiety. Hence, contrary to our expectations, higher levels of anxiety did not impede the chance of PGT for individuals scoring higher in SPS. Although overall heightened anxiety could

Table 3 Comparison of regression models ($N = 2382$). Sensitivity and depression in predicting PTG dimensions

	New possibilities					Relations with others					Spirituality					Personal power					Life appreciation				
	R2	low	up	Looic	w	R2	low	up	Looic	w	R2	low	Up	Looic	w	R2	low	up	Looic	w	R2	low	up	Looic	w
Main	.008	.004	.013	7770	.34	.010	.006	.016	7566	.26	.013	.008	.019	**7678**	**1.0**	.010	.006	.016	8280	.21	.018	.012	.026	8000	.37
Interaction	.009	.006	.015	**7769**	**.66**	.012	.008	.018	**7564**	**.78**	.014	.008	.020	7680	.0	.012	.008	.019	**8278**	**.79**	.020	.013	.027	**7999**	**.63**

The main effect models include sensitivity and depression as predictors on PTG facets. The interaction effect models include depression in interaction with sensitivity in predicting PTG facets

Looic leave-one-out cross-validation information criterion, *w* model weight

Table 4 Estimated parameters of the meaningful main and interaction effect models ($N = 2382$)

	New possibilities		Relations with others		Personal Power		Spirituality		Life appreciation	
	Median(MAD)	90%CI	Median(MAD)	90%CI	Median(MAD)	90%CI	Median(MAD)	90%CI	Median(MAD)	90%CI
Anxiety										
Main							SPS, .10(.03)	**.06,.15**	SPS, .12(.03)	**.07,.17**
							ANX, .09(.02)	**.06,.12**	ANX, .13(.02)	**.10,.17**
Interaction	−.04(.02)	**−.07, −.01**	−.04(.02)	**−.08, −.01**	**−.0**6(.02)	**−.10, −.02**				
Depression										
Main							SPS, .14(.03)	**.10,.18**		
							DEP, .003(.02),	−.02,.03		
Interaction	−.03(.02)	**−.06, −.003**	−.03 (.02	**−.06, −.004**	−.04(.02)	**−.07, −.01**			−.03(.02)	**−.06, −.001**

SPS Sensory Processing Sensitivity, *ANX* Anxiety, *DEP* Depression

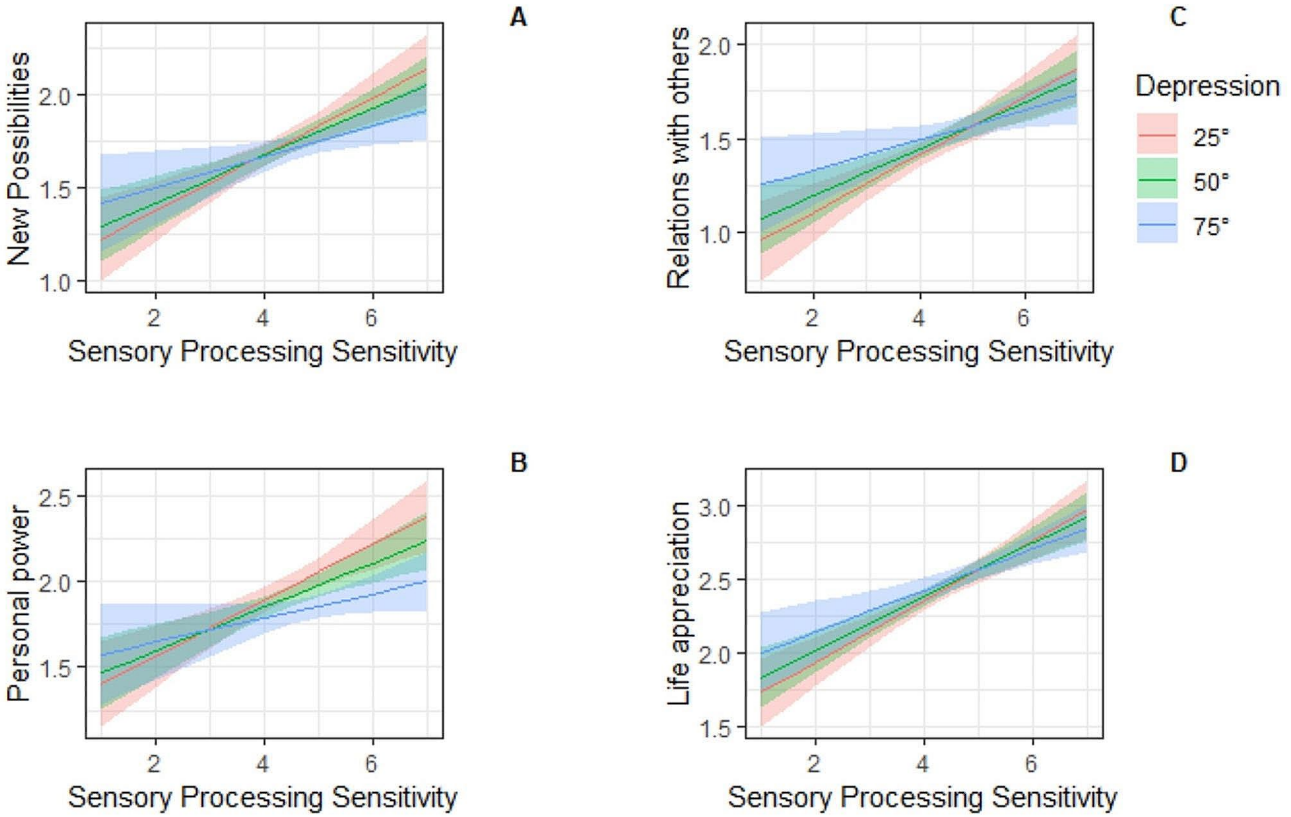

Fig. 2 SPS and Depression in predicting PTG domains. SPS and depression interaction in predicting New Possibilities (**A**), Personal Power (**B**), Relations with Others (**C**) and Life appreciation (**D**) PTG domains. As reported in the result section, for Changes in Spirituality, a main effect model was supported. The moderating variable of depression was divided in low (below the first 25th quantile), medium, and high levels (above the forth – 75th – quantile)

be dysfunctional, the "right dose" of anxiety may enable people, including highly sensitive ones, to experience PTG. Similarly, it could also mean that individuals must appraise the event as distressing in order to experience PTG as a form of adaptation to the challenge. To note, people in our sample reported levels of anxiety that were comparable to those reported in the validation study adopting the DASS measure in an Italian population (Bottesi et al., 2015), suggesting that overall experienced feelings of fear and worries were not elevated at the time of data collection. We may hypothesize that during the first phase of lockdown individuals were able to find support in the community or that this early period of lockdown due to COVID-19 was likely experienced not as a highly overwhelming period, but rather as a time of rest and reduced stimulation from everyday demands. And this may have been especially true for highly sensitive individuals, who may benefit more than others from less highly stimulating environments, as often it is at work or when confronted with everyday out-of-home demands. When anxiety was low, only individuals with higher SPS levels experienced growth suggesting a stronger contribution of SPS to PTG. Conversely, individuals with lower levels of sensitivity seemed to need higher levels of anxiety in order to experience opportunities for growth.

For depression, findings were more consistent with our hypothesis. SPS predicted higher PTG, with the highest growth when depression was low. These interaction effects were applicable to all PTG dimensions except for Change in Spirituality, for which the main SPS effect model was supported as better than the interaction effect model. That is, SPS predicted higher spirituality involvement irrespective of depression levels, comparable to what we found in relation to the anxiety dimension. This result seems to suggest that highly sensitive people are likely to be more involved in religious and existential questions, something that have been previously reported in clinical practice (Aron, 2002) but not investigated empirically yet. When depression was high, the effect of SPS on growth was present to some extent, but trivial as Bayesian credible interval and follow-up exploration of interactions. It may be that depressive feelings, contrariwise to anxiety feelings, could decrease the individual

possibility to react actively when a collective trauma occurs. This may be also due to the fact that, based on meta-analytic findings, depression counts less to PTG compared to anxiety (Long et al., 2021). In other words, higher extent of anxiety – even within the moderate range – may prompt people, especially highly sensitive, to reflect and find new meanings and opportunities, enabling them to experience PTG as a form of adaptation to the challenging event. Conversely, high levels of depression may more likely only hamper the individual resources for responding when facing the event.

To conclude, moving beyond a resilience perspective and the for-better-and-for-worse dichotomous conceptualization, the current findings overall suggest that people with higher levels of ES are not only less resilient and more vulnerable than individuals with lower levels of ES in adverse conditions, but they also have the potential of growing after the exposure to a collective traumatic event. It might be that highly sensitive people, due to their deeper processing of stimuli, openness, and attention to details (Lionetti et al., 2018; Bröhl et al., 2022), are also more able to notice alternative life paths or personal strengths to a greater extent than less sensitive ones, contributing to their growth, irrespective of the anxiety levels. It might be also that they process the traumatic experiences deeper and grow as a function of that; alternatively it could be that the early lockdown of COVID-19 was experienced as a time for rest and for reflecting more on life meaning and opportunities. Conversely, people with lower levels of ES - who are generally more resilient in the face of environmental stressors - seemed to be more resistant to positive change following a critical event, unless that event was associated with high anxiety and depression. In other words, likely due to their higher sensory thresholds, they seemed to need a higher volume of negative emotions for experiencing something as a source of change and adaptation. Individuals with lower levels of SPS may not reflect on a traumatic event when they do not experience anxiety and depression in relation to it. In other words, contrary to highly sensitive people who may be more responsive also to low levels of anxiety and depression, people low in sensitivity may simply not be traumatised to a degree that it would cause changes.

Strengths, limitations, and future directions

To our knowledge, this study is the first to analyse the role of environmental sensitivity and anxiety and depression in explaining levels of PTG during a worldwide public health emergency on a large sample size, with participants from the Italian general population. Findings provide empirical evidence that highly sensitive people are not necessarily only more vulnerable when facing adversities, but also potentially able to grow more strongly after a collective traumatic event when they perceived such event as being not excessively overwhelming in relation to depression, and irrespective of anxiety levels. However, findings should also be considered in light of some limitations. First, data are based on a cross-sectional design employing self-report questionnaires. Self-reported data, particularly on PTG, could be susceptible to cognitive biases, such as social desirability and growth beliefs, that could affect findings (see Gower et al., 2022 for meta-analytic findings on cognitive biases in perceived post-traumatic growth). Future studies should consider adopting longitudinal design for understanding better the phenomenon of post-traumatic growth, ideally using repeated measures for capturing potential dynamic fluctuations across time. Second, the sample included mostly women. Of importance, women were previously found to experience higher levels of PTG during COVID-19 (Chen et al., 2021; Collazo Castiñeira et al., 2022). A plausible explanation for the skewed sample towards women could be related to a social bias according to which women could be more interested in completing survey on emotional experiences, at least in western contexts. Future studies should explore these interactive patterns in a more balanced sample in terms of gender. Third, while the COVID-19 outbreak allowed to study PTG in the general population, the results are not generalizable to other potentially traumatic contexts that pertain to the individual rather than to the society at large (e.g., response to a medical diagnosis, death of a loved one, etc.) without further empirical investigation in other independent samples and contexts. Future studies may examine whether these associations can be generalized to other adverse events that are recurrent and/or long-lasting, as having to deal with a chronic medical diagnosis, something that has not been explored thus far. Moreover, we did not directly assess whether COVID-19 lockdown was perceived as stressful and traumatic for all participants and it may be that the anxiety levels we considered were typical of that specific subject and did not change much because of COVID-19. Forth, our findings are limited to a specific population and country and to a specific event that, besides being traumatic, at least in its beginning (our data were collected during the first national lockdown), was also characterized by a stronger sense of community bonds. Finally, we also acknowledge that people severally affected by the virus, and potentially more impacted by the event, may not have been able to engage in the survey.

Conclusion

Investigating the association between environmental sensitivity and post-traumatic growth for the first time, the current study provides novel empirical evidence that highly sensitive people are not only more susceptible to averse rearing experiences,

but also potentially more open to experience PTG, likely due to their deeper processing of experiences. Exploring the moderating role of anxiety and depression we further found that PTG was present in people with higher levels of sensitivity when anxiety was low, likely because they are more affected by low anxiety than low less sensitive individuals. These latter may not experience a growth when they don't experience anxiety in relation to the potentially traumatic event. It seems that for individuals with lower levels of sensitivity there was the need of high anxiety levels, suggesting the need of higher levels of emotions for experiencing a change. In addition, pertaining to depression, individuals with higher levels of sensitivity experienced a higher PTG when depression was low (compared to high depression levels). Overall, findings from this study open towards the possibility that highly sensitive people may not only be more vulnerable in response to negative events, but also potentially experience positive life changes when exposed to a contingent traumatic condition, integrating the concept of PTG in the study of individual differences in sensitivity.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12144-024-06208-w.

Acknowledgements The authors would like to thank all participants. The study was not pre-registered.

Author contribution Conceptualization: Francesca Lionetti, Maria Spinelli, Michael Pluess. Methodology: Alessandra Sperati, Ilenia Passaquindici, Domenico Straziuso, Gilberto Gigliotti. Formal analysis and investigation: Alessandra Sperati. Writing - original draft preparation: Alessandra Sperati. Writing - review and editing: Francesca Lionetti, Ughetta Moscardino, Mirco Fasolo. Supervision: Francesca Lionetti, Michael Pluess. All authors read and approved the final manuscript.

Funding Open access funding provided by Università degli Studi G. D'Annunzio Chieti Pescara within the CRUI-CARE Agreement. The authors did not receive support from any organization for the submitted work.

Data availability All data are openly available online at GitFront at the following link: https://gitfront.io/r/user-8766068/E3ou69ToEQAm/Sensory-Processing-Sensitivity-And-Post-Traumatic-Growth/.

Declarations

Ethics approval Approval was obtained from the ethics committee of Department of Neuroscience, Imaging and Clinical Sciences, University G. d'Annunzio, Chieti-Pescara, Italy. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent Informed consent was obtained from each participants.

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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