Original Preprint

(Accepted in *Journal of Personality Assessment*)

Environmental Sensitivity in Adults: Psychometric Properties of the Japanese

Version of the Highly Sensitive Person Scale 10-Item Version

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Declarations

Funding | This study was funded by JSPS KAKENHI Grant Numbers 19J00270 for the first author (Iimura, S.), 19J20902 for the second author (Yano, K.).

Conflicts of interest | There is no conflict of interest with regard to this manuscript.

Availability of data and material | The data that support the findings of this study are available from the corresponding author, [S.I.], upon reasonable request.

Authors' contributions | Shuhei Iimura: Conceptualization, Investigation, Data analysis, Writing- Original draft preparation; Kosuke Yano: Investigation, Data analysis, Writing- Original draft preparation. Yukiko Ishii: Investigation, Writing- Original draft preparation.

Citation

Iimura, S., Yano, K., & Ishii, Y. (2022). Environmental Sensitivity in Adults: Psychometric Properties of the Japanese Version of the Highly Sensitive Person Scale 10-Item Version. *Journal of Personality Assessment*.

This document is the author's final accepted version of the journal article. There may be differences between this version and the published version.

Abstract

Environmental Sensitivity, which explains individual differences in the tendency to respond more to both positive and negative environmental influences, can be measured by the self-reported Highly Sensitive Person scale. This paper introduced psychometric properties of a brief Japanese version of a 10-item measure of sensitivity (HSP-J10) developed by four studies involving 2,388 adults. The results showed that (1) the newly created HSP-J10 supported the bifactor structure (i.e., Ease of Excitation, Low Sensory Threshold, Aesthetic Sensitivity, plus General Sensitivity factor), (2) the HSP-J10 correlated with but discriminated against other personality traits and affects, (3) it had high temporal stability, and (4) participants who scored higher on the HSP-J10 showed significant increases in positive emotion from before watching a video with positive content to after, while those who scored low showed no significant change in positive emotion. It demonstrated the new scale's good psychometric properties in that it moderated outcomes as theoretically expected when the environment was experimentally manipulated. The four studies suggested that the newly created HSP-J10 might adequately measure individual differences in adults' *Environmental Sensitivity*.

Keywords: highly sensitive person; sensory processing sensitivity; differential susceptibility; environmental sensitivity; vantage sensitivity; temperament

Environmental Sensitivity in Adults: Psychometric Properties of the Japanese Version of the Highly Sensitive Person Scale 10-Item Version

Introduction

As has been suggested by influential developmental theories such as the bioecological model of human development (Bronfenbrenner & Morris, 2006), from birth to death, humans are affected by a wide range of environmental influences, and we undergo neurophysiological and psychosocial development through dynamic interactions with these environments. In this sense, humans are social beings that cannot be separated from their environment. However, it is important to note that individual differences in sensitivity to environmental influences can be observed (e.g., Aron et al., 2012; Belsky & Pluess, 2009; Boyce & Ellis, 2005; Ellis et al., 2011; Monroe & Simons, 1991; Pluess & Belsky, 2013). Some individuals are more likely to be susceptible to both positive and negative experiences than others. Currently, such individual differences in sensitivity to the environment are being empirically studied from the perspectives of developmental psychology, neurophysiology, behavioral genetics, molecular genetics, and personality psychology within the integrated framework of *Environmental Sensitivity Theory* (Greven et al., 2019; Pluess, 2015). In this paper, we discuss our development of a brief Japanese version of the Highly Sensitive Person (HSP) scale to measure individual differences in sensitivity in adults (Aron & Aron, 1997; Takahashi, 2016), and provide new information on its psychometric properties.

Environmental Sensitivity, defined as individual differences in the tendency to process and register external stimuli, is one of the general characteristics observed in humans and many other species (Pluess, 2015). Since the 1990s, several promising psychological concepts and theories have explained individual differences in sensitivity based on an evolutionary foundation. Typical examples are Aron's *Sensory Processing Sensitivity* (Aron & Aron, 1997; Aron et al., 2012), Belsky's *Differential Susceptibility Theory* (Belsky, 1997; Belsky & Pluess, 2009), and Boyce's *Biological Sensitivity to Context Theory* (Boyce & Ellis, 2005). Although these were established from different theoretical backgrounds, these share the central idea that about 30% of the population are more susceptible to both supportive and adversarial experiences than the rest of the population (Lionetti et al., 2018; Pluess et al., 2018; Pluess et al., 2020). More recently, *Environmental Sensitivity Theory* has been introduced, which integrates these different theories into an umbrella framework (Greven et al., 2019). As with the aforementioned existing theories,

this new framework has at its core the notion that humans differ in their tendency to process and register both positive and negative environmental influences. This theory postulates that heightened sensitivity tends to be reflected by certain features of the central nervous system (Pluess, 2015). In addition, one of the central assumptions of this theory (*Neurosensitivity Hypothesis*) suggests that heightened susceptibility of the central nervous system develops through direct and interactive effects from sensitivity genes and the early environment (Pluess, 2015).

Sensory Processing Sensitivity, which is *Environmental Sensitivity* as a personality trait, can be measured with the HSP scale in adults (Aron & Aron, 1997; Pluess et al., 2020), the Highly Sensitive Child (HSC) scale in children (Pluess et al., 2018; Weyn et al., 2021), and the HSC-Rating System (HSC-RS) by observer rating in children (Lionetti et al., 2019). The English version of the HSP scale (Aron & Aron, 1997) consists of 27 items developed based on interviews with adults, and the HSC scale (Pluess et al., 2018) consists of 12 items and was developed based on the HSP scale. Both HSP/HSC scales include three subscales: Ease of Excitation (EOE: i.e., being easily overwhelmed by internal or external stimuli), Low Sensory Threshold (LST: i.e., sensitivity to subtle external stimuli), and Aesthetic Sensitivity (AES: i.e., susceptible to aesthetic stimuli such as music or art)¹. EOE and LST subscales are composed of items that represent sensitivity to negative stimuli, and AES subscale is composed of items that reflect sensitivity to positive stimuli. Recent studies have reported that the HSP scale supports a bifactor structure (i.e., three subscales plus a *General Sensitivity* factor that explains all items) (Lionetti et al., 2018; Pluess et al., 2020). It has been translated into several languages, including Italian (Nocentini et al., 2018), Dutch (Weyn et al., 2019), and Japanese (Kibe & Hirano, 2019; Takahashi, 2016), and has been reported to have good psychometric properties for measuring individual differences in *Environmental Sensitivity*. Longitudinal studies using these scales have shown that individuals who score higher on the HSP/HSC scales are more likely to be affected by the quality of parenting (Slagt et al., 2018) and school environment (Iimura & Kibe, 2020) and by positive psychological interventions (Nocentini et al., 2018). Moreover, a more recent behavioral genetic study using a British twin sample with adolescents revealed that the heritability of *Environmental Sensitivity*, as measured by the HSC scale, was 47% (Assary et al., 2020).

¹ Originally, the HSP scale was created to measure unidimensionality (Aron & Aron, 1997), and subsequent research has identified three subscales (e.g., Smolewska et al., 2006). Although they do not have a strong theoretical basis, empirical findings suggesting the existence of subscales are beginning to accumulate.

Furthermore, functional magnetic resonance imaging (fMRI) studies have demonstrated that individuals with higher scores on the HSP scale are more likely to have activated brain regions such as the insula and dorsolateral prefrontal cortex (DLPFC) when presented with emotional stimuli (Acevedo et al., 2014).

Sensitivity, as measured by the HSP scale, has been demonstrated to be related to, but uniquely structured from, other personality traits and affects. For example, a recent meta-analysis found weak to moderate positive correlations between the HSP scale and the *Big Five* personality traits of *Openness* ($r = .14$) and *Neuroticism* ($r = .40$) in adults, but no significant correlations with *Extraversion* and *Agreeableness* or *Conscientiousness* (Lionetti et al., 2019). In children, the HSC scale was positively correlated with *Neuroticism* ($r = .42$). Furthermore, the HSP scale was positively correlated with *Negative Affect* ($r = .34$) in adults, while the HSC scale was positively correlated with both *Positive* ($r = .21$) and *Negative Affect* ($r = .29$) in children. Behavioral genetic findings have reported that 80% of the heritability of sensitivity as measured by the HSC scale shares genetic effects with *Neuroticism* and *Extraversion*, and the remaining 20% is explained by genetic effects specific to sensitivity (Assary et al., 2020).

A central notion of *Environmental Sensitivity* is that highly sensitive individuals are more likely to be affected, for better and for worse, depending on the quality of the environmental influences (Greven et al., 2019). Findings supporting this view have been provided mainly in the field of developmental psychology (e.g., Belsky et al., 2019; Keers et al., 2016; Kochanska et al., 2011; Rudolph et al., 2020). In a study examining the effects of the Parenting x Temperament interaction on child development (Slagt et al., 2018), highly sensitive children ($M+1SD$), as evaluated by the HSC scale, had increased externalizing behaviors from an increase in negative parenting, while their externalizing behaviors decreased with reduced negative parenting. In contrast, regardless of the degree of negative parenting, the externalizing behavior of children with low sensitivity ($M-1SD$) did not change. This illustrates that highly sensitive children were more likely to be affected by the parenting quality, for better and for worse. More recently, it has been confirmed that *Environmental Sensitivity* also moderates the positive effects of a supportive environment (e.g., Iimura & Kibe, 2020; Kibe et al., 2020; Nocentini et al., 2018; Pluess & Boniwell, 2015). For example, highly sensitive children are more likely to benefit (e.g., lower depression and anxiety) from school-based positive psychological interventions (e.g., resilience training and bullying prevention interventions), which is called

Vantage Sensitivity. In addition, children with low sensitivity are less likely to benefit from a supportive environment, which is called *Vantage Resistance*. The *Vantage Sensitivity Theory* (Pluess, 2017; Pluess & Belsky, 2013) explains such individual differences in susceptibility to positive environmental stimuli, i.e., individuals with high sensitivity are more likely to experience the benefits of positive experiences from a supportive environment because of their traits.

The HSP scale, which can easily measure *Environmental Sensitivity* by self-report, is expected to accelerate the accumulation of knowledge in this area. However, Pluess et al. (2020), who developed a new short version of the HSP scale, pointed out that while the sensitivity scale performs well in children, its ability to measure sensitivity in adults requires further improvement. This is not a problem limited to the English version of the sensitivity measure; the Japanese version of the HSP scale (HSP-J19), which consists of 19 items, has a similar issue. For example, several studies using the HSP-J19 have reported low internal consistency of the AES subscales ($\alpha < .60$; Takahashi, 2016). This may be because the AES subscale contains items with low factor loadings. In addition, temporal stability has not been examined. It is also important to note that it has not been demonstrated whether individuals rated as highly sensitive, based on the HSP-J19 scale, are in fact susceptible to environmental influences. Experimental or longitudinal studies are needed to test this. Hence, this article focuses on developing a brief version of the HSP scale that has good psychometric properties and can easily measure the sensitivity of Japanese adults with fewer items.

The Current Study

In order to create a psychometrically robust sensitivity measure, we conducted four studies that included a total of 2,388 Japanese adults. In Study 1, we conducted an exploratory examination to determine whether the same three-factor structure (i.e., EOE, LST, and AES) as in previous studies could be replicated (Pluess et al., 2020; Smolewska et al., 2006; Takahashi, 2016), and created a short version of the scale consisting only of items with high factor loadings. In Study 2, we confirmed whether the newly created concise version of the scale supports the bifactor structure as well as the existing findings (Lionetti et al., 2018; Pluess et al., 2018; Pluess et al., 2020). We also examined its correlation with personality traits and affects. In Study 3, we examined the temporal stability of the scale, and also examined whether the associations with personality traits and affects shown in Study 2 could be replicated. In Study 4, we conducted an

experiment using a video to induce positive emotions, and examined whether participants who scored high on the newly developed scale had an increase in positive emotions pre- to post-video viewing (i.e., evidence for *Vantage Sensitivity*). The hypotheses in each study are provided in their sections.

In summary, the connections between the studies are as follows: Considering the *Environmental Sensitivity Theory* and the existing scale structure, Study 1 focused on identifying the factor structure of the scale's shortened version. Based on the results of Study 1, Studies 2 and 3 examined further psychometric properties of the scale by testing for correlations with other temperaments and affects that could be theoretically relevant. In addition to the evidence from Studies 2 and 3, Study 4 focused on examining whether the scale reflects individual differences in sensitivity by experimentally manipulating the environment.

Study 1

In Study 1, we aimed to create a brief version of the HSP-J19 using a large sample of Japanese adults. To develop a psychometrically robust scale, we began by performing an Exploratory Factor Analysis and only included items with high factor loadings in the scale. If prior findings from the Japanese population can be replicated (Takahashi, 2016; Yano et al., 2020), it is expected that the concise version of the scale can be composed of three subscales (EOE, LST, and AES) that have also been identified in Western populations (Pluess et al., 2020; Smolewska et al., 2006).

Methods

Participants and Procedures

To create a brief version of the HSP-J19, participants were recruited through a social research company (Cross Marketing Inc.). We conducted a web-based survey and collected data from 1,626 adult Japanese participants². Participants were given points exchangeable for cash as rewards. The mean age of the participants was 29.9 years ($SD = 13.8$, $Min = 18.0$, $Max = 69.0$), and 867 (53%) were female. 74% of the participants were attending or had graduated from college, and 53.4% of them were students at the time. The most frequent (mode) value of household income (18.3%) was less than 2,000,000 JPY (approximately 19,016 USD). To avoid

² Originally, 2,201 Japanese were recruited, but 575 who inappropriately rated items on the Directed Questions Scale (Maniaci & Rogge, 2014), which measures inattentional tendencies, were removed from the study.

influencing their responses, we did not inform the participants about the true purpose of the study in advance. The institutional review board of Rikkyo University approved all procedures in Study 1 (No. KOMI19001A).

Development of the Brief Version of HSP Scale.

The participants completed the HSP-J19 scale using a 7-point Likert-type scale, ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Since this study used a scale already translated in a previous study (Takahashi, 2016), we did not translate this scale anew. All the items of the HSP-J19 can be found in Supplementary Material Table S1. This scale consists of 8 items from the EOE subscale (e.g., *Do changes in your life shake you up?*), 7 items from the LST subscale (e.g., *Are you bothered by intense stimuli, like loud noises or chaotic scenes?*), and 4 items from the AES subscale (e.g., *Do you notice and enjoy delicate or fine scents, tastes, sounds, or works of art?*). Cronbach's alpha for HSP-J19 was .86 (.83 for EOE, .84 for LST, and .57 for AES). All mean scores were as follows: HSP-J19 was 4.21 ($SD = 0.76$), EOE was 4.13 ($SD = 1.09$), LST was 4.20 ($SD = 1.17$), and AES was 4.30 ($SD = 0.99$).

In order to develop the short version of the HSP-J19 scale with sufficient psychometric properties, we aimed to select items with factor loadings of 0.50 or higher in previous studies (Pluess et al., 2020). Consequently, the 10-item brief version of the scale (HSP-J10) was constructed, including a 5-item EOE subscale, a 3-item LST subscale, and a 2-item AES subscale. Table 1 shows the list of selected items and their factor loadings.

Data Analysis

First, we explored the optimal number of factors based on parallel analysis, Velicer's minimum average partial (MAP) tests, and scree plots. Second, based on the recommended number of factors, an Exploratory Factor Analysis with promax rotation was performed. Given the characteristics of the data collected, that is, (1) the theoretical assumption of normal distribution (Greven et al., 2019; Weyn et al., 2021), (2) relatively large sample size ($n = 1,626$), (3) small skewness of the distribution (kurtosis = 3.13, skewness = -0.00), and (4) seven categories of response options, we used the maximum likelihood estimation method for factor analysis. Items with factor loadings lower than 0.50 were deleted and the analysis was repeated until all items had factor loadings of 0.50 or higher. Third, the internal consistency of the scale was evaluated based on the traditionally used Cronbach's α and the model-based estimate of McDonald's ω total. Both are classified as acceptable at .70 or higher (e.g., McNeish, 2018;

Watkins, 2017). Forth, we calculated the descriptive statistics and internal consistency of the newly created HSP-J10. The correlation coefficients between the HSP-J10 and HSP-J19 were also calculated. No missing values were included in the analyzed data. To run these analyses, we used R, version 3.6.3 (R Core Team, 2020) and its interface, RStudio, version 1.2.5033 (RStudio Team, 2019).

Results

Consequently, the parallel analysis recommended seven factors, the MAP test one factor, and the scree plot three factors. Based on theory and existing evidence (e.g., Pluess et al., 2020; Smolewska et al., 2006), we determined that the short version of the scale consists of three factors: EOE, LST, and AES. Based on three factors the Exploratory Factor Analysis finally retained 10 items with factor loadings exceeding 0.50 (Table 1)³. Cronbach’s alpha for the HSP-J10 was good with .82 (McDonald’s $\omega = .88$). Internal consistency showed .83 ($\omega = .83$) for the EOE, .79 ($\omega = .80$) for the LST, and .72 for the AES ($\omega = .74$; two-item correlation was $r = .57, p < .001$). As shown in Supplementary Material Figure S1, the HSP-J10 scores were characterized by a normal distribution. The mean score of HSP-J10 was 4.24 ($SD = 0.96$), EOE was 4.30 ($SD = 1.20$), LST was 3.97 ($SD = 1.40$), and AES was 4.46 ($SD = 1.37$). The correlation coefficient between HSP-J10 and HSP-J19 was $r = .94$ (95%CI [.94, .95]), $r = .95$ (95%CI [.94, .95]) for EOE, $r = .88$ (95%CI [.86, .89]) for LST, and $r = .80$ (95%CI [.78, .82]) for AES.

[Table 1]

Discussion

The purpose of Study 1 was to create a brief version of the HSP-J19 consisting only of items with high factor loadings. We started by identifying the optimal number of factors, and the results suggested that the same three-factor structure (i.e., EOE, LST, and AES) as in previous studies (Pluess et al., 2020; Smolewska et al., 2006) was appropriate. Additional analyses shown in the footnotes and supplementary materials suggested that the HSP-J10 can also be well explained by unidimensionality and, similar to previous studies, the total score of this scale can capture sensitivity to both positive and negative aspects (e.g., Greven et al., 2019; Slagt et al., 2018). The newly developed HSP-J10 showed almost the same mean score as that of the HSP-

³ Since recent existing evidence supports the HSP scale’s bifactor structure in terms of both *Environmental Sensitivity Theory* and model fit, we also analyzed our data using Bifactor Exploratory Structural Equation Modeling (B-ESEM; Morin et al., 2016) to examine whether the data in this study fit. As shown in Supplementary Material Figure S2, our data also showed a high fit to the bifactor structure ($\chi^2 = 21.55, df = 11, p = .028, CFI = 1.00, RMSEA = 0.02, SRMR = 0.01$).

J19 ($M = 4.24$ vs. 4.21), and also exhibited a very high positive correlation between the two ($r = .94$). Fortunately, when we constructed the HSP-J10 with only items with high factor loadings, the internal consistency of the AES ($\alpha = .72$) improved significantly over that of the HSP-J19 ($\alpha = .57$). Previous studies using HSP-J19 suggested that there was a problem with the internal consistency of the AES (e.g., Takahashi, 2016; Yano & Oishi, 2018), but we solved this problem by deleting items with small contributions to the AES. Taken together, the psychometric properties of HSP-J10 not only approximated those of the HSP-J19, but also improved the internal consistency of the AES subscale.

Study 2

The purpose of Study 2 was twofold. The first was to determine whether the HSP-J10 created in Study 1 statistically supports the bifactor structure using the newly collected data. From the perspective of both *Environmental Sensitivity Theory* and goodness of model fit, existing evidence from Western samples has supported that the HSP scale consists of three subscales plus a *General Sensitivity* factor that explains all items (e.g., Lionetti et al., 2018; Pluess et al., 2020). Hence, we expected the bifactor structure to be reproduced using data from the adult Japanese population. Second, we examined how the HSP-J10 and its subscales correlate with personality traits (i.e., *Big Five* personality traits, behavior inhibition, and behavior activation) and affects (i.e., trait anxiety, depressive symptoms, positive affect, and negative affect). A recent meta-analysis showed that the 27-item HSP scale correlated positively with *Neuroticism* ($r = .40$) and *Openness* ($r = .14$), and with *Negative Affect* ($r = .34$) (Lionetti et al., 2019). However, since these are findings derived mainly from Western data, it is unclear whether Japanese data can replicate them. In addition, it has been noted that there may be cultural differences in the relationship between sensory processing sensitivity and other personality traits (e.g., Greven et al., 2019; Iimura & Kibe, 2020). Given these current conditions, the authors were unsure whether they could preliminarily assume an association in the Japanese sample similar to the findings reported in the Western sample. Therefore, we did not set a specific hypothesis, but exploratively examined the association between HSP-J10 and personality traits and affects.

Methods

Participants and Procedures

We conducted a mixed-device survey, a method often used because of recent

developments in survey technology. The second author recruited participants through an online survey service (Cross Marketing Inc.), and the first author recruited participants from a first-year university class at a university in Tokyo (Google Forms). Finally, we collected data from 416 Japanese adults of which 206 (49.5%) were female. Prior research has reported that differences in the devices used to complete the survey do not significantly affect aspects such as quality of responses and response time (Revilla et al., 2016). In our study, we could not identify significant mean differences in the total score of the HSP scale (Cohen's $d = 0.19$) based on recruiting methods, although there were differences in some of the other variables, including the HSP subscales (only for LST, AES), *Behavioral Activation System*, *Extraversion*, *Agreeableness*, *Conscientiousness*, *Openness*, and *Positive Affect* ($d = 0.30$ – 1.08).

The mean age of the participants was 37.9 years ($SD = 13.8$, $Min = 18.0$, $Max = 59.0$). 26% of the participants were university students. The participants completed the questionnaires. Participants who completed the survey through a social research company were rewarded with points that could be exchanged for cash, while students who participated in the study through their university classes were rewarded with course credits. To avoid influencing their responses, we did not inform the participants about the true purpose of the study in advance. The institutional review board of Rikkyo University and the University of Tokyo approved all procedures in Study 2 (No. KOMI20003A and 20-135).

Measures

Sensitivity. To measure sensitivity, we used the HSP-J10 developed in Study 1. The internal consistency was acceptable with Cronbach's $\alpha = .86$ for the HSP-J10 ($\omega = .85$), .85 for the EOE ($\omega = .85$), .77 for the LST ($\omega = .82$), and .60 for the AES ($\omega = .61$).

Personality Traits. (1) We used a Japanese version of the Ten Item Personality Inventory to assess the *Big Five* personality traits (Oshio et al., 2012). This scale measures the *Big Five*, that is, *Neuroticism* (e.g., *Anxious*, *easily upset*.), *Extraversion* (e.g., *Extraverted*, *enthusiastic*.), *Openness* (e.g., *Open to new experiences*, *complex*.), *Agreeableness* (e.g., *Critical*, *quarrelsome*.), and *Conscientiousness* (e.g., *Dependable*, *self-disciplined*.), in a simple way with two items each (one of which is a reversed item). Each item is rated on a 7-point Likert-type scale, ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). The two-item correlation for each facet showed $r = .27$ for *Neuroticism*, $r = .49$ for *Extraversion*, $r = .31$ for *Openness*, $r = .16$ for *Agreeableness*, and $r = .35$ for *Conscientiousness* ($ps < .001$). (2) The 20-item Japanese version of

the BIS/BAS scales (Takahashi et al., 2007), which measures the behavioral inhibition system (BIS) and the behavioral activation system (BAS) was used to examine the association with HSP-J10. The BIS scale consists of 7 items (e.g., *I worry about making mistakes.*), and the BAS scale includes 13 items (e.g., *When I get something I want, I feel excited and energized.*). Each item was rated on a four-point Likert-type scale, ranging from 1 (*strong disagreement*) to 4 (*strong agreement*). The internal consistency was .82 for the BIS and .88 for the BAS.

Affects. (1) To measure trait anxiety as a negative affect, a 20-item trait anxiety subscale was used from the Japanese version of the State-Trait Anxiety Inventory (STAI-J) (Shimizu & Imae, 1981). Items (e.g., *I am tense, I am worried.*) were rated on a four-point Likert-type scale, ranging from 1 (*never*) to 4 (*always*). Cronbach's alpha was .92 in the sample. (2) The Japanese version of Center for Epidemiologic Studies Depression Scale (CES-D) was used to assess depressive symptoms (Shima et al., 1985). This scale consists of 20 items (e.g., *I felt depressed, I felt lonely.*) and asks how many depressive symptoms participants have experienced in the past week using a four-point Likert-type scale, ranging from 0 (*Rarely or none of the time; less than 1 day*) to 3 (*Most or all the time; 5-7 days*). The internal consistency of 20 items was .90. (3) The 16-item Japanese version of the Positive and Negative Affect Schedule (Sato & Yasuda, 2001) was used to measure affects. This scale contains an eight-item *Positive Affect* subscale (e.g., *enthusiastic, interested*) and an eight-item *Negative Affect* subscale (e.g., *scared, afraid*). Participants scored the items on a six-point Likert-type scale, ranging from 1 (*not at all*) to 6 (*extremely*). The internal consistencies of *Positive Affect* and *Negative Affect* were good with Cronbach's alpha = .89 and .92, respectively.

Data Analysis

First, we examined whether the HSP-J10 supports the bifactor structure (i.e., EOE, LST, AES, plus *General Sensitivity* factor) using Confirmatory Factor Analysis with the maximum likelihood estimation method. The goodness of fit of the model was comprehensively evaluated based on several indices, including a comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). For CFI, >.90 is acceptable. For RMSEA and SRMR, <.08 is satisfactory. Second, the bivariate correlation coefficients between all variables were calculated to examine the relationship between HSP-J10 and the related concepts (i.e., personality traits and affects). To perform these analyses, we used Mplus, version 8.3. (Muthén & Muthén, 1998-2017) and R, version 3.6.3 (R Core Team, 2020).

Finally, we excluded from the analysis one participant who used the same answers for all items.

Results

The fit indices, except for the RMSEA criterion, showed that HSP-J10 was a good fit with the bifactor structure ($\chi^2 = 128.684$, $df = 29$, $p < .001$, CFI = 0.95, RMSEA = 0.09, SRMR = 0.05). The loadings from each factor to the items are shown in Figure 1. The distribution and mean scores of HSP-J10 in Study 2 ($M = 4.11$) were similar to those of HSP-J10 and HSP-J19 in Study 1 ($M = 4.24$ and 4.21 , respectively; Supplementary Material Figure S2). According to the correlation coefficients shown in Table 2, the HSP-J10 showed a negative weak correlation with *Extraversion* ($r = -.27$, 95%CI [-.36, -.18]) and *Conscientiousness* ($r = -.10$, 95%CI [-.20, -.01]), and a positive moderate correlation with *Neuroticism* ($r = .37$, 95%CI [.28, .45]) and BIS ($r = .46$, 95%CI [.38, .53]). In addition, the HSP-J10 was positively correlated with trait anxiety ($r = .46$, 95%CI [.38, .54]), depressive symptoms ($r = .41$, 95%CI [.32, .49]), and *Negative Affect* ($r = .48$, 95%CI [.40, .55]). A similar trend of correlation was confirmed for all subscales of the HSP-J10 (see Table 2 for details).

[Table 2 & Figure 1]

Discussion

The bifactor model explaining HSP-J10 showed a good fit with our data and reproduced the Western findings (Lionetti et al., 2018; Pluess et al., 2020). Therefore, our findings suggest that there may be a common factor structure for *Environmental Sensitivity*, regardless of whether one is Western or Eastern (note that configural invariance needs to be investigated in future studies). In contrast, and interestingly, the results on the relationship with personality traits and affects were partially different from the Western findings. For example, a meta-analysis by Lionetti et al. (2019) found correlations in *Neuroticism* and *Openness* only, while the HSP-J10 was not clearly correlated with *Openness*. However, given that the positive correlation between sensitivity and *Openness* in the meta-analysis was mainly derived from the AES subscale, the fact that the Japanese data showed only a weak correlation with *Openness* may be explained by the inclusion of only two items AES subscales in the HSP-J10. Other possibilities are that these inconsistencies may depend on ethnicity or culture. To clarify this question, however, it is necessary to examine whether the association between *Environmental Sensitivity* and personality traits and affects is moderated by ethnicity or culture, using data that include both Western and Eastern cultures. In summary, given that the correlation coefficients of HSP-J10 with personality

traits and affects were weak to moderate, it is suggested that sensitivity measured by the HSP-J10 is an independent structure different from them.

Study 3

Studies 1 and 2 provided evidence for the factor structure of HSP-J10 and its association with other psychological concepts. In order to further examine the psychometric properties of the HSP-J10, Study 3 investigated the following two questions. The first was to examine the temporal stability of the newly created HSP-J10. Several studies have reported that sensitivity, as measured by the HSP scale, is a stable concept within individuals (e.g., Konrad & Herzberg, 2019). Therefore, we also expected that sensitivity measured using the HSP-J10 again about two months after Study 2 would show high stability. The second was to examine whether the findings from Study 2 could be replicated, we calculated the correlation coefficients between the personality traits and affects measured in Study 2 and the HSP-J10 measured in Study 3.

Methods

Participants and Procedures

We followed the same procedure as in Study 2, recruiting all Japanese adults who had participated in Study 2 ($n = 416$) to complete the survey again. The same web-based survey was conducted approximately two months after Study 2. Finally, there were 261 participants (37% attrition from Study 2), with 130 females (50%). The average age of the participants was 36.7 years ($SD = 14.1$, $Min = 18.0$, $Max = 59.0$), and 38% were students. To avoid influencing their responses, we did not inform the participants about the true purpose of the study in advance. The institutional review board of Rikkyo University and the University of Tokyo approved all procedures in Study 3 (No. No. KOMI20003A and 20-135).

Measures

Sensitivity. The participants completed the HSP-J10 scale again (see the Methods section of Study 1 for details). The mean values were 4.08 ($SD = 1.00$) for HSP-J10, 4.11 ($SD = 1.25$) for EOE, 4.25 ($SD = 1.30$) for LST, and 3.87 ($SD = 1.37$) for AES. The distribution of the HSP-J10 was similar to Study 1 and Study 2 (Supplementally Material Figure S3). The internal consistency showed .84 for HSP-J10 ($\omega = .85$), .86 for EOE ($\omega = .86$), .73 for LST ($\omega = .78$), and .58 for AES ($\omega = .70$).

Personality Traits and Affects. We used the data measured in Study 2: The Japanese version of the Ten Item Personality Inventory (Oshio et al., 2012), the Japanese version of the BIS/BAS scales (Takahashi et al., 2007), the Japanese version of the State-Trait Anxiety Inventory (Shimizu & Imae, 1981), and the Japanese version of the Positive and Negative Affect Schedule (Sato & Yasuda, 2001). See the Methods section of Study 2 for details.

Data Analysis

First, to evaluate the temporal stability of sensitivity measured by the HSP-J10, the correlation coefficients between the HSP-J10 and its subscales measured at Study 2 and Study 3 were calculated. Based on Cohen’s (1992) criteria, we expected to show a large effect size, $r > .50$. Second, we calculated the correlation coefficients between the HSP-J10 and its subscales and personality traits and affects. We also evaluated whether the findings of Study 2 could be replicated. All analyses were conducted on R, version 3.6.3 (R Core Team, 2020) and its interface RStudio, version 1.2.5033 (RStudio Team, 2019).

Results

As Table 3 shows, the HSP-J10 and its subscales were confirmed to have high temporal stability. The correlation coefficients between the two time points were .71 (95%CI [.65, .77]) for the HSP-J10, .71 (95%CI [.64, .76]) for EOE, .63 (95%CI [.55, .70]) for LST, and .65 (95%CI [.58, .72]) for AES, indicating high temporal stability. The HSP-J10 showed moderate correlation with BIS ($r = .50$, 95%CI [.40, .58]) and *Neuroticism* ($r = .39$, 95%CI [.29, .49]) and negatively correlated with *Extraversion* ($r = -.22$, 95%CI [-.33, -.11]), replicating Study 2, but was almost no correlation with *Agreeableness* ($r = .04$, 95%CI [-.08, .16]) and *Conscientiousness* ($r = -.07$, 95%CI [-.18, .05]). In addition, the HSP-J10 correlated moderately with trait anxiety ($r = .51$, 95%CI [.42, .59]), depressive symptoms ($r = .39$, 95%CI [.28, .48]), and *Negative Affect* ($r = .42$, 95%CI [.32, .51]), replicating Study 2, but almost no correlation with *Positive Affect* ($r = -.11$, 95%CI [-.22, .01]) was found. As shown in Table 3, overall, the subscales of the HSP-J10 showed a similar trend.

[Table 3]

Discussion

Study 3 aimed to investigate the further psychometric properties of the HSP-J10 by examining its temporal stability and its relationship to related concepts including personality

traits and affects. Our analysis confirmed that sensitivity, as measured by HSP-J10 and its subscales, shows high temporal stability. This underpins the definition of sensitivity, which is characterized as a personality trait or temperament (Aron et al., 2012). Correlational examinations also supported conceptual differences with other personality traits and affects. Importantly, Studies 2 and 3 shared common associations with *Neuroticism*, *Extraversion*, BIS, trait anxiety, depressive symptoms, and *Negative Affect*, which indicates that our findings are robust. Albeit in part, this also replicated the Western findings. In summary, Study 3 suggested that sensitivity, as measured by HSP-J10, is highly temporally stable and can be discriminated from other psychological concepts.

Study 4

Studies 1 to 3 suggested that the newly created HSP-J10 has psychometric properties to adequately measure adults' *Environmental Sensitivity*. The last part of this article, namely Study 4, reported the moderating effect of sensitivity as measured by the HSP-J10 in a positive emotion induction experiment. According to the notion of *Vantage Sensitivity* (known as the bright side of *Environmental Sensitivity Theory*), highly sensitive individuals are more likely to benefit from the positive effects of supportive experiences because of their characteristics (Greven et al., 2019; Pluess, 2017; Pluess & Belsky, 2013). In contrast, individuals with low sensitivity are less likely to be affected by positive experiences (i.e., *Vantage Resistance*). Indeed, several studies examining the effects of positive psychological interventions have demonstrated that highly sensitive individuals benefited more from interventions than low-sensitivity individuals (Kibe et al., 2020; Nocentini et al., 2018; Pluess & Boniwell, 2015). If our newly created HSP-J10 is a validated measure to assess sensitivity, it is expected to moderate the relationship between positive experiences and their consequences, as in previous works. To examine this, we tested whether the change in positive emotion accompanying the viewing of a short positive video can be moderated by the HSP-J10 score. We hypothesized that highly sensitive individuals would have significantly increased positive emotions following the viewing of a positive video, compared to low-sensitivity individuals.

Methods

Participants

This study included 85 first-year university students from Hosei University in Tokyo.

The mean age of the students was 18.8 years ($SD = 0.6$, $Min = 18.0$, $Max = 20.0$) and 65% ($n = 55$) of students were female. All participants were Japanese. Students received course credit for their participation. The institutional review board of the University of Tokyo approved all procedures in Study 4 (No. 20-135).

Procedures

The first author announced the prospect of participating in the psychological experiment to first-year university students who were taking a class offered in the fall semester. In exchange for course credit and after providing informed consent, students who expressed interest in participating partook in an online-based emotion induction experiment. To begin, students rated their sensitivity and status of positive emotion. Next, the students watched a short positive video that lasted about five minutes. The video was about a soldier returning to the U.S. from war and reuniting with his son or daughter as a surprise. The video used in the experiment can be found at this link (<https://bit.ly/3rDQaFo>). Finally, immediately after watching the video, students rated their state of positive emotions again. To avoid influencing their responses, we did not inform the participants about the true purpose of the study in advance. Additionally, to exclude participants from the data who did not read the content of the items carefully (i.e., high propensity for inattention), we used the Directed Questions Scale (Maniaci & Rogge, 2014). As a result, all participants were sufficiently attentive.

Measures

Sensitivity. The HSP-J10 was used to measure sensitivity (see Study 1 for details). The mean value of the HSP-J10 scale was 4.62 ($SD = 0.9$) and was characterized by a normal distribution (Supplementary Material Figure S4). The internal consistency of this scale was good with Cronbach's $\alpha = .78$ ($\omega = .85$).

Positive Emotion. To measure positive emotions before and after watching the video, an eight-item *Positive Affect* subscale from the Japanese version of the Positive and Negative Affect Schedule was used (see Study 2). In this study, the participants were asked to respond to their current state. The internal consistency of this scale showed .85 before and .86 after viewing the video.

Data Analysis

First, the correlation coefficients between the variables used in this study were calculated

to describe the relationship between the variables. Next, to test our hypothesis, we performed a linear mixed-effects regression model assuming a random intercept. This model included gender, centralized HSP-J10, and Time as main effects, and the interaction between centralized HSP-J10 and Time was entered as an interaction effect. If the HSP-J10 x Time interaction was significant, a simple slope test was performed to compare the regression lines of students with high ($M+1SD$; *about top 26% in this sample*) and low ($M-1SD$) HSP-J10 scores, respectively. All analyses were conducted on R, version 3.6.3 (R Core Team, 2020) and its interface RStudio, version 1.2.5033 (RStudio Team, 2019). The lme4 package (Bates et al., 2015) was used to run the mixed-effects model.

Results

Table 4 shows the correlation coefficients among all the variables in this study; the HSP-J10 showed a positive correlation with *Positive Affect* after watching the video ($r = .42, p < .01$). Thus, the HSP-J10 was not associated with the variables measured at baseline.

[Table 4]

As shown in Table 5, a linear mixed-effects model predicting changes in *Positive Affect* following viewing of the video revealed a significant interaction effect of HSP-J10 and Time ($b = 0.28, t(83) = 3.62, p < .001$). Importantly, a simple slope test showed a significant increase in *Positive Affect* from pre- to post-video viewing only in highly sensitive individuals ($b = 0.52, t(83) = 5.20, p < .001$), suggesting *Vantage Sensitivity*. In contrast, individuals with low sensitivity did not show significant changes in *Positive Affect* from pre- to post-video viewing ($b = 0.01, t(83) = 0.07, p = .945$), suggesting *Vantage Resistance*. The differences in the regression lines between individuals with high and low sensitivity are depicted in Figure 2.

[Table 5 and Figure 2]

Discussion

In Study 4, to further test the psychometric properties of HSP-J10, we experimentally examined whether it moderates changes in *Positive Affect* across the pre- and post-viewing of video with positive content. Our hypothesis was supported, and only participants who scored high ($M+1SD$) on the HSP-J10 were observed to experience increased *Positive Affect*. This result provides experimental evidence for the *Vantage Sensitivity* (Pluess, 2017; Pluess & Belsky, 2013). Given this theory, it is possible that positive emotions were induced by the positive video because highly sensitive people are more likely to process information more deeply and have

heightened emotional reactivity to environmental stimuli as demonstrated by experimental studies (e.g., Acevedo et al., 2014; Acevedo et al., 2017; Jagiellowicz et al., 2016). Conversely, as reported in several studies and in our results, individuals with low sensitivity are less likely to benefit from positive interventions (e.g., Nocentini et al., 2018) and supportive environment (e.g., Iimura & Kibe, 2020). In summary, Study 4 demonstrated that the newly created HSP-J10 measures individual differences in sensitivity or responsiveness to positive stimuli.

General Discussion

We introduced the psychometric properties of the HSP-J10, a brief version of the HSP-J19 that measures temperamental and personality aspects of *Environmental Sensitivity*, by conducting four studies involving 2,388 Japanese adults. To begin, given the findings on the English version of the HSP scale (Lionetti et al., 2018; Pluess et al., 2020), we used Exploratory Factor Analysis to explore whether large-scale Japanese data would yield three factors (i.e., EOE, LST, and AES). In addition, we used Confirmatory Factor Analysis to confirm whether the newly created HSP-J10 supports the bifactor structure (i.e., three subscales plus *General Sensitivity* factor). Furthermore, based on the findings of the meta-analysis that tested the relationship between sensitivity and personality traits and affects (Lionetti et al., 2019), we also examined whether the sensitivity measured by HSP-J10 can be differentiated from these concepts. Moreover, given that sensitivity measured by the self-reported scale is tied to personality traits or temperament (Greven et al., 2019), we clarified the temporal stability of sensitivity as measured by the HSP-J10. Finally, based on the *Vantage Sensitivity Theory* (Pluess, 2017; Pluess & Belsky, 2013), which postulates that highly sensitive people are more likely to experience the positive effects of a supportive environment, we experimentally tested whether the HSP-J10 can moderate the changes in positive emotions induced by the viewing of a video.

Study 1 revealed that the newly developed HSP-J10 is composed of the same three factors as the HSP-J19 (Takahashi, 2016), and the English version (Pluess et al., 2020; Smolewska et al., 2006), although the items included are slightly different. The EOE subscale consisted of five items that reflect sensitivity traits that are easily influenced by internal or external environmental stimuli (e.g., *Are you easily overwhelmed by strong sensory input?*). The LST subscale consisted of three items reflecting a low sensory threshold for unpleasant external stimuli (e.g., *Are you bothered by intense stimuli, like loud noises or chaotic scenes?*). The AES

subscale consisted of two items that reflected susceptibility to music and art (e.g., *Are you deeply moved by the arts or music?*). Given that the correlation coefficient between HSP-J10 and HSP-J19 is extremely high ($r = .94$), it is suggested that the short version scale replicates the psychometric properties of HSP-J19. It is noteworthy that the newly created AES subscale ($\alpha = .72$), despite its two items, improved internal consistency over that of the HSP-J19 ($\alpha = .57$). Although Cronbach's alpha tends to be low when the number of items is small (McNeish, 2018), its implementation is actually an improvement since we have succeeded in extracting items that contribute more to the AES factor. For example, the AES subscale of the HSP-J19 includes the item "*I am conscientious*," but this item was removed from the HSP-J10. This item seems to reflect the *Conscientiousness* of the Big Five rather than aesthetic sensitivity: It is important to note that there is almost no correlation between AES and *Conscientiousness* (see Table 2 and 3).

Study 2 provided two new pieces of evidence for the psychometric properties of HSP-J10. First, the HSP-J10 underpins the bifactor structure, replicating Western findings (Lionetti et al., 2018; Pluess et al., 2020). Given that the bifactor structure has also been identified in scales used to measure sensitivity in Japanese and Western children (Iimura & Kibe, 2020; Pluess et al., 2018), it is possible that the structure of *Environmental Sensitivity* is stable across a lifespan. Although the examination of ethnic and cultural differences in *Environmental Sensitivity* is an important topic in this research area (Greven et al., 2019), and knowledge about it is very limited, our findings suggest that the structure of *Environmental Sensitivity* in the Japanese populations is partially shared with that in Western populations. Second, our data supported that sensitivity measured by HSP-J10 is an independent construct from other personality traits and affects. For example, similar to Western findings (Lionetti et al., 2019), the HSP-J10 showed a moderate positive correlation with *Neuroticism* and *Negative Affect*. Interestingly, however, unlike the Western findings, the HSP-J10 showed a negative association with *Extraversion*. Given our findings, the structure of *Environmental Sensitivity* may be similar in both the West and the East, but which personality traits and emotions are associated with *Environmental Sensitivity* may be culture dependent. It is expected that direct comparison of Eastern and Western data, such as measurement invariance and differences in means, will help elaborate the concept of *Environmental Sensitivity*.

Study 3 revealed that the HSP-J10 ($r = .71$) and its subscales ($r = .63-.71$) have high temporal stability. The German version of the HSP scale (Konrad & Herzberg, 2019) shows r

= .88 (the subscales: $r = .81-.86$), and the English version of the HSC scale (Pluess et al., 2018) indicates $r = .68$ (the subscales: $r = .57-.78$); these previous findings as well as our own suggest that sensitivity, as measured by the HSP scale, is a temporally stable trait, albeit over a period of several months. The development of *Environmental Sensitivity* over a life-span is currently unclear, but more repeated measurements over a long-term time span using the HSP scale will aid in advancement of our understanding.

Study 4 provided the first experimental evidence that Japanese people with high sensitivity are more likely to experience the positive effects of a supportive environment. Specifically, individuals who scored high on the HSP-J10 showed significantly increased *Positive Affect* after viewing a positive video (i.e., *Vantage Sensitivity*). In contrast, individuals with low sensitivity had almost no change in their *Positive Affect* pre- to post-video viewing (i.e., *Vantage Resistance*). In other words, the HSP-J10 moderated the relationship between the positive environmental stimuli and the positive outcomes resulting from it. Our findings were consistent with the *Vantage Sensitivity Theory*, which is related to the “bright side” of the differential susceptibility framework (Pluess & Belsky, 2013). The mechanism of *Vantage Sensitivity* assumes genetic variants that influence endophenotypic neurobiological features involved in a wide range of behaviors, including sensitivity to positive environmental influences (Pluess, 2017). The association between genetic variants involved in *Vantage Sensitivity* and the HSP-J10 is not clear. Still, if the relationship is clarified, it will add important insights that will advance our knowledge of *Environmental Sensitivity* and the psychometric properties of HSP-J10. Nevertheless, Study 4 established the satisfactory psychometric properties of HSP-J10 in terms of its involvement in *Vantage Sensitivity*. Further experimental investigation of the “dark side” of differential susceptibility, i.e., whether sensitive individuals are more likely to be negatively affected by an adversarial environment, would advance our understanding of the individual differences in sensitivity.

As mentioned above, this study has several strengths, including using a large Japanese sample and the experimental manipulation of the environment to validate the new scale, and some notable limitations. First, the validation of the newly developed HSP-J10 was done mainly in association with self-report-based scales (e.g., Studies 1-3). To further examine the psychometric properties of the scale, future studies could include assessing its consistency with reports by others (Weyn et al., 2021), examining its association with a polygenic score of

sensitivity (Keers et al., 2016), examining the heritability of sensitivity in a Japanese sample (Assary et al., 2020), and examining the association with activation in specific regions of the brain (Acevedo et al., 2021) would be useful. Second, the data in this study included a relatively large sample of university students (especially Study 4). Future studies may need to consider whether the findings of this study can be replicated in samples with lower levels of education. Third, to ensure data quality in Studies 1 and 4, we used the Directed Questions Scale (Maniaki & Rogge, 2014) to identify participants with a high propensity for inattention; however, we did not conduct these inattention checks in Studies 2 and 3 (note that we excluded participants who responded the same to all items). Fourth, a potential concern pointed out by a recent review states that existing HSP scales, including the new scale created by us, contain a relatively large number of negatively worded items (Greven et al., 2019). In light of this, it may be desirable for future studies to control for negative emotions that could potentially be associated with these scales in their analyses.

Taken together, with four studies involving a total of 2,388 participants, we introduced the psychometric properties of the HSP-J10 and provided new evidence on the individual differences in *Environmental Sensitivity* of the adult Japanese population. The newly developed HSP-J10 showed similar psychometric properties to the English version of the HSP scale, i.e., bifactor structure and high temporal stability. In addition, highly sensitive Japanese people reported lower *Extraversion*, higher *Neuroticism*, higher behavior inhibition, and higher *Negative Affect*. Furthermore, it has been experimentally shown that Japanese people with high sensitivity have a significantly increased *Positive Affect* after watching a video that evokes positive emotions, compared to people with low sensitivity. In conclusion, Japanese adults differ in their sensitivity to environmental influences, and these individual differences can easily be measured by a newly developed 10-item scale, the HSP-J10.

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Table 1
Factor Structure of the HSPS-J10 in Study 1 (N = 1,626)

	EOE	LST	AES	<i>h</i> ²
1. Do changes in your life shake you up? (EOE)	0.90	-0.14	-0.03	0.65
2. Are you easily overwhelmed by strong sensory input? (EOE)	0.67	0.20	0.05	0.69
3. Do other people’s moods affect you? (EOE)	0.66	-0.06	0.05	0.40
4. Do you get rattled when you have a lot to do in a short amount of time? (EOE)	0.64	0.06	0.00	0.46
5. When you must compete or be observed while performing a task, do you become so nervous or shaky that you do much worse than you would otherwise? (EOE)	0.55	0.07	-0.07	0.34
6. Are you bothered by intense stimuli, like loud noises or chaotic scenes? (LST)	-0.09	0.93	-0.06	0.75
7. Are you made uncomfortable by loud noises? (LST)	-0.01	0.80	-0.01	0.62
8. Are you easily overwhelmed by things like bright lights, strong smells, coarse fabrics, or sirens close by? (LST)	0.11	0.52	0.05	0.38
9. Do you notice and enjoy delicate or fine scents, tastes, sounds, works of art? (AES)	0.02	0.08	0.78	0.65
10. Are you deeply moved by the arts or music? (AES)	-0.04	-0.08	0.75	0.53

Note. EOE = Ease of excitation, LST = Low sensory threshold, AES = Aesthetic sensitivity. *h*² = Communality.

Table 2
Correlation Coefficients and Descriptive Statistics in Study 2 (N = 416)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	M	SD
1. HSP	—														4.11	1.07
2. EOE	.91 **	—													4.06	1.26
3. LST	.81 **	.57 **	—												4.33	1.35
4. AES	.64 **	.42 **	.38 **	—											3.88	1.30
5. BIS	.52 **	.61 **	.28 **	.22 **	—										2.85	0.59
6. BAS	.04	.02	.00	.11 *	.13 **	—									2.73	0.50
7. E	-.31 **	-.36 **	-.18 **	-.12 *	-.32 **	.39 **	—								3.82	1.51
8. A	-.10 *	-.11 *	-.13 **	.07	.00	.15 **	.06	—							4.92	1.08
9. C	-.15 **	-.23 **	-.05	.03	-.19 **	.06	.17 **	.13 *	—						3.81	1.30
10. N	.44 **	.57 **	.18 **	.14 **	.67 **	.05	-.32 **	-.18 **	-.25 **	—					4.06	1.29
11. O	-.07	-.18 **	.02	.12 *	-.24 **	.37 **	.44 **	.04	.22 **	-.20 **	—				3.77	1.30
12. STAI-T	.53 **	.63 **	.32 **	.16 **	.65 **	-.09	-.46 **	-.24 **	-.29 **	.71 **	-.32 **	—			2.36	0.58
13. CES-D	.46 **	.52 **	.31 **	.13 **	.46 **	-.13 **	-.31 **	-.29 **	-.24 **	.53 **	-.17 **	.77 **	—		0.80	0.52
14. NA	.53 **	.58 **	.34 **	.23 **	.54 **	.06	-.31 **	-.19 **	-.21 **	.58 **	-.14 **	.71 **	.64 **	—	2.62	1.06
15. PA	-.12 *	-.20 **	-.05	.06	-.16 **	.51 **	.50 **	.14 **	.28 **	-.22 **	.43 **	-.38 **	-.38 **	-.02	2.88	0.90

Note. HSP = HSP-J10 total score, EOE = Ease of excitation, LST = Low sensory threshold, AES = Aesthetic sensitivity, BIS = Behavior inhibition system, BAS = Behavior activation system, E = Extraversion, A = Agreeableness, C = Conscientiousness, N = Neuroticism, O = Openness, STAT-T = Trait anxiety, CES-D = Depressive symptoms, NA = Negative affect, PA = Positive affect.

* $p < .05$, ** $p < .01$

Table 3
Test-Retest Reliability for the HSP-J10 and Correlations with Personality Traits and Affects in Study 3 (N = 261)

	HSP T2	EOE T2	LST T2	AES T2
HSP T1	.71 **	.55 **	.57 **	.51 **
EOE T1	.65 **	.71 **	.50 **	.31 **
LST T1	.54 **	.35 **	.63 **	.26 **
AES T1	.52 **	.28 **	.25 **	.65 **
BIS T1	.50 **	.53 **	.37 **	.24 **
BAS T1	.02	.01	-.03	.07
E T1	-.22 **	-.28 **	-.13 *	-.10
A T1	.04	-.05	.04	.10
C T1	-.07	-.23 **	-.02	.08
N T1	.39 **	.57 **	.20 **	.15 **
O T1	-.02	-.16 **	.02	.09
STAI-T T1	.51 **	.61 **	.36 **	.21 **
CES-D T1	.39 **	.46 **	.30 **	.14 *
NA T1	.42 **	.50 **	.28 **	.19 **
PA T1	-.11	-.20 **	-.13 *	.07

Note. T1 = Time 1 (Study 2). T2 = Time 2 (Study 3). HSP = HSP-J10 total score, EOE = Ease of excitation, LST = Low sensory threshold, AES = Aesthetic sensitivity, BIS = Behavior inhibition system, BAS = Behavior activation system, E = Extraversion, A = Agreeableness, C = Conscientiousness, N = Neuroticism, O = Openness, STAT-T = Trait anxiety, CES-D = Depressive symptoms, NA = Negative affect, PA = Positive affect. Test-retest reliability is shown in bold.

* $p < .05$, ** $p < .01$

Table 4
Mean, Standardized Deviation, and Bivariate Correlation among All Variables in Study 4 (N = 85)

	1	2	3	<i>M</i>	<i>SD</i>
1. Gender (male = 1, female = 2)	—			—	—
2. HSP	0.06	—		4.62	0.93
3. Positive affect (Pre)	-0.21	0.19	—	2.19	0.80
4. Positive affect (Post)	-0.18	0.42 **	0.71 **	2.45	0.97

Note. HSP = HSP-J10 total score. Pre = just before watching a positive video. Post = just after watching a positive video.

** $p < .01$

Table 5
Results of Mixed-Effects Regression Model Predicting Pre-Post Change in Positive Affect

Predictors	Estimates	95%CI	SE	<i>t</i>	<i>df</i>	<i>Pr(> t)</i>
Fixed Effects						
(Intercept)	2.80	[2.24, 3.36]	0.29	9.78	84.53	<.001
Gender (male = 1, female = 2)	-0.38	[-0.71, -0.05]	0.17	-2.26	82.00	.024
HSP	0.18	[-0.01, 0.37]	0.10	1.85	111.27	.065
Time	0.26	[0.13, 0.40]	0.07	3.73	83.00	<.001
HSP×Time	0.28	[0.13, 0.43]	0.08	3.62	83.00	<.001

Note. HSP = HSP-J10 total score. *N* = 85.

Figure 1.
Bifactor Structure of HSP-J10 in Study 2 (N = 416)

Note. EOE = Ease of excitation, LST = Low sensory threshold, AES = Aesthetic sensitivity. HSP = General sensitivity factor. $\chi^2 = 128.684$ ($df = 29$), $p < .001$, CFI = 0.95, RMSEA = 0.09, SRMR = 0.05. All path coefficients from general sensitivity factor to each item were statistically significant ($p < .001$).

Figure 2.
Comparison of Slopes for High and Low Sensitivity in Study 4 (N = 85).

Note. Estimated values are respectively, $M+1SD$: $b = 0.52$, 95%CI [0.32, 0.72], $SE = 0.10$, $df = 83.00$, $t = 5.20$, $p < .001$; $M-1SD$: $b = 0.01$, 95%CI [-0.19, 0.20], $SE = 0.10$, $df = 83.00$, $t = 0.07$, $p = 0.945$.