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Environmental sensitivity predicts interpersonal sensitivity above and beyond Big Five personality traits

Benjamin A. Tabak [a,*], Drishtant Gupta [a], Cecile S. Sunahara [a], Talha Alvi [a], Zachary Wallmark [b], Junghee Lee [c], Daniel Fulford [d], Nathan W. Hudson [a], Michael Chmielewski [a]

[a] Department of Psychology, Southern Methodist University, Dallas, TX, USA
[b] Department of Musicology and Ethnomusicology, University of Oregon, Eugene, OR, USA
[c] Department of Psychiatry and Behavioral Neurobiology, University of Alabama at Birmingham, Birmingham, AL, USA
[d] Departments of Occupational Therapy and Rehabilitation Sciences and Psychological & Brain Sciences, Boston University, Boston, MA, USA

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ABSTRACT

We investigated whether environmental sensitivity, as measured by the Highly Sensitive Person Scale (HSPS), predicts constructs related to interpersonal sensitivity above and beyond Big Five traits. In Study 1 ($N = 1377$), we first examined the HSPS factor structure and found a two-factor solution to be most optimal. We then found that the two HSPS factors were significantly associated with constructs related to three domains of interpersonal sensitivity such as empathy (positive interpersonal sensitivity), social anxiety (negative interpersonal sensitivity), and theory of mind (social cognitive ability), and explained unique variance above and beyond neuroticism, extraversion, agreeableness, and openness. In Study 2 ($N = 1240$), we replicated most of these findings after statistically controlling for all Big Five personality traits.

1. Is environmental sensitivity separable from Big Five traits?

To date, studies have found evidence that higher levels of environmental sensitivity, as measured by the Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997), are associated with negative outcomes including anxiety and depression (Bakker & Moulding, 2012; Liss et al., 2008), but also positive outcomes including empathy (Acevedo et al., 2014), creativity (Bridges & Schendan, 2019), and reward responses to positive socioemotional stimuli among participants who had supportive early childhood environments (Acevedo et al., 2017). However, recent research has called into question whether environmental sensitivity explains unique variance above and beyond Big Five personality traits. Specifically, Hellwig and Roth (2021) found that three HSPS factors did not predict emotion recognition after accounting for associations with the Big Five.

There are several potential explanations for these results. The first is that the results of Hellwig and Roth (2021) may be related to their use of a German translation of the HSPS that includes several differences from the original scale, including the removal of original items (Konrad & Herzberg, 2017). Another explanation is that the results from Hellwig and Roth (2021) may be related to their use of three HSPS factors to examine associations of environmental sensitivity and emotion recognition. Indeed, researchers using the HSPS have examined total scores, and/or two, three, or more subscales, which may contribute to different results. Given that there are numerous behavioral tasks that are used to assess emotion recognition, another potential explanation for Hellwig and Roth's (2021) findings is that environmental sensitivity may be related to performance on other tasks assessing social cognition, as well as other constructs related to interpersonal sensitivity above and beyond Big Five traits.

Thus, in the present study, we first examined the factor structure of the HSPS scale across three samples. Next, we examined associations of the resultant two-factor solution with constructs related to three broad types of interpersonal sensitivity as assessed via self-report and behavioral tasks. Importantly, we did so when controlling for several Big Five traits. We then conducted a direct replication study in which we controlled for all Big Five traits.

1.1. Defining environmental sensitivity and measurement using the HSPS

Environmental sensitivity has been defined as a type of reactivity or responsiveness to both positive and negative factors in the environment

* Corresponding author at: Department of Psychology, Southern Methodist University, 6116 N. Central Expressway, Suite 1300, Dallas, TX 75206, USA.
E-mail address: btabak@smu.edu (B.A. Tabak).

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(Lionetti et al., 2019). It has been conceptualized as a unifying construct that combines theories of genetic and neurobiological variability that are associated with individual differences in sensitivity or reactivity to external stimuli (Belsky & Pluess, 2009; Boyce & Ellis, 2005). Sensory processing sensitivity—a temperament trait involving "…greater depth of information processing, increased emotional reactivity and empathy, greater awareness of environmental subtleties, and ease of over-stimulation" (p. 288; Greven et al., 2019) (as defined in Aron & Aron, 1997; Homberg et al., 2016)—is theorized to represent a self-report assessment of environmental sensitivity. Currently, the Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997) is the only self-report assessment of sensory processing or environmental sensitivity.

The initial scale development study identified a unitary construct with a total HSPS score (Aron & Aron, 1997), but subsequent psychometric analyses have typically identified more than one factor. Evans and Rothbart (2008) identified two HSPS factors, "Negative Affect" and "Orienting Sensitivity," which they refer to as correlates of the Big Five personality dimensions neuroticism and openness to experience, respectively. In contrast, the three-factor solution identified by Smolewska et al. (2006) separated the "Negative Affect" factor into two factors that they called "Ease of Excitation" (i.e., being overwhelmed by internal and external stimuli) and "Low Sensory Threshold," (i.e., unpleasant or undesirable sensory experiences to external stimuli) while largely maintaining the additional "Orienting Sensitivity" or openness factor which they referred to as "Aesthetic Sensitivity" (i.e., awareness of and the extent to which music and art evoke a response). As in Smolewska et al. (2006), Hellwig and Roth (2021) found a three-factor solution best fit the German translation of the HSPS. They then examined these three factors in relation to emotion recognition, while controlling for the Big Five. A more recent psychometric analysis described a bi-factor model of the HSPS that included the total score as well as a three-factor model (Lionetti et al., 2018).

1.2. Defining interpersonal sensitivity

Historically, there have been several different ways that researchers have defined interpersonal sensitivity (Table 1), including being socially adept, accurate, and skilled in the assessment of others' thoughts and intentions (Hall et al., 2009); a disposition or trait of people who are caring, empathic, and attuned to others in need (Decety & Batson, 2007); or a construct related to psychopathology or risk for the development of psychopathology, particularly in relation to depression, social anxiety, or rejection sensitivity (Boyce & Parker, 1989; Derogatis et al., 1974; Marin & Miller, 2013).

Based on these definitions, it is clear that interpersonal sensitivity is a multifaceted construct without one single agreed upon definition (Bernieri, 2001). Although studies typically focus on one aspect or correlate of interpersonal sensitivity, we believe that it is informative to examine three broad domains (positive interpersonal sensitivity, negative interpersonal sensitivity, and social cognitive ability) to determine the extent to which environmental sensitivity is associated with constructs related to different forms of interpersonal sensitivity. Below are brief descriptions of the constructs included in each domain of interpersonal sensitivity.

1.2.1. Positive interpersonal sensitivity

Based in part on the definition provided by Decety and Batson (2007), in the present study we define *positive interpersonal sensitivity* as the tendency, frequency, or extent to which one engages in other-oriented processes (attention, cognition, emotion, etc.) out of genuine concern for the well-being of others. In Table 2, we include a list of constructs related to positive interpersonal sensitivity that assess these tendencies including empathy, sociality, affiliation, and prosociality.

Importantly, we make a distinction between *self-reported* empathy and *behaviorally* assessed empathy or social cognitive ability (which we have separated into its own domain). This distinction is based on research showing that self-reports and behavioral assessments of empathy are only weakly correlated (Murphy & Lilienfeld, 2019). In Table 2, constructs related to positive interpersonal sensitivity are largely assessed via self-report. Self-report measures of empathy assess the tendency to experience emotions through contagion or in response to a target (i.e., affective empathy), and the tendency, as well as perceived ability, to understand what a target is thinking or feeling (i.e., cognitive empathy) (De Waal & Preston, 2017; Gonzales-Liencres et al., 2013). A related construct is sociality, which involves the tendency to form social connections (Helgeson, 1994; Wiggins, 1991), the value and enjoyment associated with engaging with close relationships, and being

Table 1
Definitions of interpersonal or social sensitivity.

Domains of Interpersonal Sensitivity	
Positive Interpersonal Sensitivity	
(Decety & Batson, 2007)	"…our ability to perceive and respond with care to the internal states (e.g., cognitive, affective, motivational) of another, understand the antecedents of those states, and predict the subsequent events that will result."
(Woolley et al., 2010)	"…how well individuals work with others."
Negative Interpersonal Sensitivity	
(Boyce & Parker, 1989)	"…undue and excessive awareness of, and sensitivity to, the behaviour and feelings of others. Individuals with this trait are…preoccupied with their interpersonal relationships, vigilant to the behaviour and moods of others, and overly sensitive to the vicissitudes of any interpersonal interaction-particularly to perceived or actual situations of criticism or rejection. Accordingly, their behaviour is generally modified to comply with others' expectations so as to minimize the risk of criticism or rejection."
(Katz et al., 1984)	"…increased sensitivity to perceived slights which, in the extreme as in some depressions, can escalate to 'suspiciousness' and ideas of reference."
(Marin & Miller, 2013)	"…a stable trait characterized by ongoing concerns about negative social evaluation. This disposition makes people vigilant for as well as sensitive to others' evaluations of them. To avoid negative social evaluation, they adopt defensive behaviors like submission and inhibition."
(O'Neill et al., 2004; Steiger et al., 1999)	"…affective reactivity to daily interpersonal stressors."
(Denollet & Duijndam, 2019)	"…characterized by ongoing concerns about negative social evaluation (Marin and Miller, 2013), and increased sensitivity to criticism from others (Keltner et al., 2003)."
(Derogatis et al., 1974)	"…feelings of personal inadequacy and inferiority, particularly in comparison to other persons. Self-deprecation, feelings of uneasiness, and marked discomfort during interpersonal interactions are characteristic manifestations, as are acute self-consciousness and negative expectancies regarding interpersonal communications."
(Somerville, 2013)	"A shifting motivation toward social relatedness is thought to intensify the attention, salience, and emotion relegated to processing information concerning social evaluations and social standing, referred to herein as social sensitivity."
Social Cognitive Ability	
(Baron-Cohen, Wheelwright, Hill, et al., 2001)	"…mind reading"
(Bernieri, 2001)	"…the ability to sense, perceive accurately, and respond appropriately to one's personal, interpersonal, and social environment."
(Riggio, 1986)	"The ability to decode and understand verbal communication and general knowledge of the norms governing appropriate social behavior…"
(Hall et al., 2009)	"…accurate judgement or recall of others' behavior or appearance."

Table 2
Constructs related to interpersonal sensitivity.

Positive Interpersonal Sensitivity	Negative Interpersonal Sensitivity	Social Cognitive Ability
Self-reported measures	*Self-reported measures*	*Behavioral measures*
General empathy	Social anxiety	Theory of Mind
Cognitive empathy	Depression	Emotion recognition
Affective empathy	Behavioral inhibition	
Sociality	Rejection sensitivity	
Affiliation	Attachment anxiety	
Prosociality	Attachment avoidance	
	Emotional reactivity	
	Personal Distress	
	Social anhedonia	

warm and affectionate (also known as affiliation; Depue & Collins, 1999). In addition to empathy and sociality, the extent to which people tend to help or share with others, often referred to as prosociality (Dunfield et al., 2019), can also be categorized as factor related to positive interpersonal sensitivity.

1.2.2. Negative interpersonal sensitivity

We define *negative interpersonal sensitivity* as the tendency, frequency, or extent to which one engages in other oriented processes (attention, cognition, emotion, etc.) due to perceived, potential, or actual distress that may be experienced. In Table 2, we include a list of constructs that are related to negative interpersonal sensitivity including psychopathology (i.e., social anxiety and depression), behavioral inhibition, rejection sensitivity, adult attachment anxiety and avoidance, emotional reactivity, and social anhedonia.

Negative interpersonal sensitivity has often been conceptualized as a predictor of psychopathology or a measure of psychopathology risk. As shown in Table 1, Derogatis et al. (1974) described interpersonal sensitivity as a characteristic represented by low self-esteem and social anxiety in interpersonal interactions. The definition by Katz et al. (1984) has some overlapping features from Derogatis et al. (1974) but includes elements of hostility and psychosis at the extreme end of the spectrum. In agreement with several previous definitions, Marin and Miller (2013) reviewed components of (negative) interpersonal sensitivity and their association with physical health outcomes and included constructs such as social anxiety and avoidance, behavioral inhibition, as well as rejection sensitivity.

High levels of social anxiety are characterized by an intense fear of criticism or evaluation, which extends into apprehension and avoidance of others (Mattick et al., 1998). Depression, which commonly co-occurs with high levels of social anxiety, has been associated with enhanced reactions to social rejection (Leary, 2001; Nezlek et al., 1997; Slavich et al., 2010). In line with our definition of negative interpersonal sensitivity, Boyce and Parker (1989) developed the Interpersonal Sensitivity Measure (IPSM) to assess a depression-prone personality style. Studies have confirmed the link between higher scores on the IPSM and depression (Boyce et al., 1991) as well as anxiety disorders (Harb et al., 2002; Wilhelm et al., 2004).

In addition to social anxiety and depression, several other constructs are also related to negative interpersonal sensitivity including behavioral inhibition, or an aversive motivational system which inhibits behavior that may result in negative outcomes (Carver & White, 1994; Gray, 1970). For people with high levels of behavioral inhibition, functioning is typically related to punishment, often resulting in withdrawal from unfamiliar people and situations (Carver & White, 1994; Panayiotou et al., 2014). Similarly, interpersonal theories of personality have maintained that perceived rejection and mistrust of others underlie interpersonal difficulties (Downey & Feldman, 1996). This sensitivity to rejection influences reactive emotional states based on the expectation of rejection in certain situations (Downey & Feldman, 1996; Downey et al., 1998; London et al., 2007). Relatedly, conceptualizations of attachment styles in adulthood focus on anxiety and avoidance dimensions of insecure attachment with the absence of both representing secure attachment (Brennan et al., 1998). Anxious attachment refers to individuals who have a strong need to be close to others but are highly concerned that their desire for closeness will not be reciprocated (in the form of rejection or possible abandonment; Brennan et al., 1998), whereas avoidant attachment characterizes individuals who are not comfortable being close, dependent, or intimate with others (Brennan et al., 1998). Thus, both anxious and avoidant attachment styles are related to our definition of negative interpersonal sensitivity. Additional correlates of negative interpersonal sensitivity include general emotional reactivity to daily interpersonal stressors (O'Neill et al., 2004; Steiger et al., 1999), as well as distress or reactivity towards others experiencing negative or aversive affective states (Batson et al., 1987; Murphy et al., 2020). Finally, as social anhedonia is related to a lack of motivation and/or interest in engaging in social activity, which is associated with social withdrawal, it is also related to our conceptualization of negative interpersonal sensitivity.

1.2.3. Social cognitive ability

Based on a long tradition of defining interpersonal sensitivity as social cognitive ability (e.g., Hall et al., 2009), in the present study, we included two behavioral tasks assessing emotion recognition and theory of mind (i.e., the ability to accurately interpret others' thoughts, intentions, and emotions; Alvi et al., 2020). A meta-analysis conducted by Hall et al. (2009) found that behavioral assessments of social cognitive ability were positively related to empathy (i.e., positive interpersonal sensitivity) and negatively associated with neuroticism and depression (i.e., negative interpersonal sensitivity).

1.3. Environmental sensitivity, interpersonal sensitivity, and Big Five traits

In a recent *meta*-analysis, the HSPS total and factor scores (identified by Smolewska et al., 2006) were associated with two Big Five personality traits: neuroticism (as well as the related construct of negative affect) and openness—but not extraversion, agreeableness, or conscientiousness (Lionetti et al., 2019). This *meta*-analysis also found associations between environmental sensitivity and behavioral inhibition. A more recent study using a 12-item version of the HSPS scale (Pluess et al., 2020) replicated these patterns of association between HSPS scores and Big Five personality traits (Bröhl et al., 2020). However, to date, only one study has examined the extent to which environmental sensitivity, as measured by the HSPS scale, is associated with dimensions of interpersonal sensitivity above and beyond Big Five traits (Hellwig & Roth, 2021).

Hellwig and Roth (2021) first outlined conceptual issues related to the construct of environmental sensitivity and then examined the extent to which the three HSPS subscales identified by Smolewska et al. (2006) were distinct from Big Five personality traits. The authors then examined whether environmental sensitivity predicted emotion recognition accuracy above and beyond Big Five traits. In two studies, the authors found that environmental sensitivity could be entirely accounted for by neuroticism, extraversion, and openness. The authors also found no unique associations between environmental sensitivity and emotion recognition accuracy when controlling Big Five traits. However, Hellwig and Roth (2021) only examined a single aspect of interpersonal sensitivity: behaviorally assessed emotion recognition. Thus, it is currently unknown whether environmental sensitivity predicts different correlates of interpersonal sensitivity above and beyond Big Five personality traits.

1.4. Study aims

In the present study, we first analyzed the factor structure of the HSPS. Next, we examined associations between the two resulting

environmental sensitivity factors and measures related to the three broad domains of interpersonal sensitivity above and beyond Big Five traits. In Study 1, we examined the three Big Five traits that have been most extensively examined in the context of interpersonal processes: neuroticism, agreeableness, and extraversion (and in a subsample, openness). In Study 2, we performed a replication and extension of Study 1 by conducting many of the same analyses when including all five Big Five traits. Some of the variables included in the present analyses have also been examined in previous studies (Alvi et al., 2020; Dinulescu et al., 2021), which focused on associations between social anxiety and social cognitive ability, and social cognitive ability and self-referential processing (i.e., neither examined environmental sensitivity or the majority of constructs related to interpersonal sensitivity as we do in the present study).

2. Study 1

2.1. Method

2.1.1. Open science

This study was not preregistered. Full information about the study materials and methods can be found at https://osf.io/4cr8b. Data is publicly available: https://osf.io/9v6wh/.

2.1.2. Participants

Participants were recruited between January 2017 and December 2017 from Southern Methodist University (SMU; $n = 553$), Boston University (BU; $n = 426$), and an online sample via Amazon's Mechanical Turk (MTurk; $n = 506$). We included seven attention check items intermittently throughout the measures to determine the overall validity of responses. Participants were removed if they completed all of the online assessments too quickly (i.e., under 20 min; $n = 118$) or answered more than 4 items incorrectly among the 7 attention checks ($n = 134$). Following the removal of these participants, our final sample totaled 1485; however, across all three samples, 108 participants did not complete the entire HSPS and were therefore removed (our primary analyses relied on factor scores which use listwise deletion in their computation; thus, participants with incomplete HSPS data could not be included). This resulted in 1377 participants (68% female, age range = 18–77 years, M age = 25.76, $SD = 11.67$, M socioeconomic status (SES) = 48.27, $SD = 11.40$); one participant did not report their age, three participants did not report their gender, and six did not report their racial/ethnic identification). Participants self-identified as White (71.5%), Black or African-American (6.2%), Asian (16.1%), and Other (5.2%). MTurk participants were awarded monetary compensation, and college students from both institutions were awarded research credit for participation. The study was approved by the Institutional Review Boards at both universities, and informed consent was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki.

2.1.3. Measures

2.1.3.1. Self-report measures. Environmental sensitivity. The 27-item Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997) was used to measure sensory processing, or environmental sensitivity (factor analysis and reliability described in the statistical analysis and results section; $n = 1377$).

Personality Traits. Personality traits were measured using the agreeableness ($\alpha = 0.81$, $n = 1351$), extraversion ($\alpha = 0.89$, $n = 1358$), openness ($\alpha = 0.79$, $n = 445$), and neuroticism ($\alpha = 0.86$, $n = 1354$) scales of the Big Five Inventory (BFI; John & Srivastava, 1999).

Positive interpersonal sensitivity related constructs. Empathy was measured with the Toronto Empathy Questionnaire (TEQ; Spreng et al., 2009), the short form of the Empathy Quotient (EQ; Wakabayashi et al., 2006), the Perspective Taking (IRI-PT) and Empathic Concern (IRI-EC) subscales of the Interpersonal Reactivity Index (IRI; Davis, 1980), the Balanced Emotional Empathy Scale (BEES; Mehrabian, 1996), the Emotional Contagion Scale (ECS; Doherty, 1997) in which positive and negative contagion were calculated separately, and the mentalizing factor (AQ-M; Palmer et al., 2015) of the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, et al., 2001) in which higher scores reflect more difficulties in self-reported mentalizing. Measures of trait level affiliation included the communion subscale (PAQ-C) of the Personal Attributes Questionnaire (PAQ; Spence et al., 1975) and the sociability factor (AQ-S; Palmer et al., 2015) of the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, et al., 2001), in which higher scores reflect more difficulties socially. The Social Value Orientations (SVO) Slider Scale (Murphy et al., 2011) was used to measure prosociality. Means, standard deviations, and reliability estimates are displayed in Supplementary Table 1.

Negative interpersonal sensitivity related constructs. Social anxiety was measured via the Social Phobia Scale (SPS; Mattick et al., 1998), the Social Interaction Anxiety Scale (SIAS; Mattick et al., 1998), the Leibowitz Social Anxiety Scale (LSAS; Liebowitz, 1987), and the Brief Fear of Negative Evaluation Scale (Leary, 1983). Participants also completed a measure of depression symptoms through the Dysphoria subscale (IDAS-D) of the Inventory of Depression and Anxiety Symptoms (IDAS-II; (Watson et al., 2012). To measure rejection sensitivity, two measures were included: the Rejection Sensitivity- Adult Questionnaire (ARSQ; Berenson et al., 2009) and the Sensitivity to Rejection Scale (MSR; Mehrabian, 1970). The Interpersonal Sensitivity Measure (IPSM; Boyce & Parker, 1989) was included as a general measure of negative interpersonal sensitivity along with a modified 18-item version (Carmichael & Reis, 2005) of the Experience in Close Relationships scale (ECR; Fraley et al., 2000) to measure adult attachment anxiety (ECR-Anx) and avoidance (ECR-Avo). Emotional reactivity was assessed via the Emotional Reactivity Scale (ERS; Nock et al., 2008). Behavioral inhibition was assessed through the use of the Behavioral Inhibition System scale (BIS; Carver & White, 1994), and the Personal Distress subscale (IRI-PD) of the IRI (Davis, 1980). Last, social anhedonia was measured via the Revised Social Anhedonia Scale (with higher scores indicating higher levels) (RSAS; Winterstein et al., 2011). Means, standard deviations, and reliability estimates are displayed in Supplementary Table 1.

Socioeconomic Status. Participants completed the Barratt simplified measure of social status (Barratt, 2006), a modified form of the Hollingshead social status index (Hollingshead, 1975), that quantifies SES during childhood based on participants' primary caregiver(s)'s occupational status and educational attainment.

2.1.3.2. Behavioral measures of social cognitive ability. Emotion recognition. The Emotion Perceptions of Biological Motion Task (Emo Bio; Heberlein et al., 2004) assesses emotion recognition through 24 videos depicting human body movement related to specific emotions (i.e., happy, sad, angry, afraid, and neutral). Emotion is conveyed through point-light displays based on specific components of body movement. Total scores were calculated as mean levels of accuracy across stimuli based on weighted normed means (as in Alvi et al., 2020).

Theory of mind. The Reading the Mind in the Eyes Test (RMET; Baron-Cohen, Wheelwright, Hill, et al., 2001) has been conceptualized as a measure of theory of mind, or the ability to understand the mental state of others. Participants were shown 36 black-and-white photographs of the eye-region of different male and female actors. After each photo was presented they chose which of four words best described the actor's feeling. As in Alvi et al. (2020), the total score was calculated based on the mean accuracy across items.

2.1.4. Procedure

As reported in Alvi et al. (2020), participants completed

questionnaires and behavioral measures (as well as other unrelated questionnaires) online via Qualtrics (Provo, UT).

2.1.5. Statistical analyses

Based on previous factor analytic evidence suggesting the HSPS has either a two- (Evans & Rothbart, 2008) or three-factor solution (Smolewska et al., 2006), we conducted an exploratory factor analysis with promax rotation and extracted both two- and three-factor solutions within each subsample separately, as well as in the overall combined sample. We evaluated whether a two- or three-factor solution was more appropriate both by calculating the coefficient of congruence (CC; Tucker, 1951) to examine the degree to which the factor loadings replicated across all three samples (i.e., SMU-BU, SMU-MTurk and BU-MTurk)—and also by examining the interpretability of the pattern of factor loadings. Following the determination that the two-factor solution was optimal (see HSPS factor analysis section below), we saved participants' factor scores on the two dimensions of HSPS—which were used in all subsequent analyses. We then examined the zero-order correlations of the two HSPS factor solution with constructs related to positive and negative interpersonal sensitivity, as well as social cognitive ability. Finally, we used hierarchical linear regression analyses (using SPSS v. 24) which included neuroticism, agreeableness, and extraversion (and in subsamples from the larger undergraduate sample, openness) in Block 1, and then both HSPS factors as predictors of each construct related to interpersonal sensitivity in Block 2.

3. Results

3.1. HSPS factor analysis

We first examined whether a two- or three-factor solution was more appropriate for the HSPS. We evaluated this in two ways. First, we examined the CCs of the factor solutions across the three subsamples. These analyses provide information regarding the extent to which the pattern of factor loadings replicated across all three samples. Second, we examined the patterns of factor loadings for interpretability.

With respect to the former, based on the criteria outlined by Lorenzo-Seva and ten Berge (2006) and MacCallum et al. (1999), CC's with values above 0.95 are considered *good* and CC's with values ranging from 0.85 to 0.94 are considered *fair*. For the two-factor model, CCs indicated an adequate degree of similarity between the factor loading matrices across the three different samples; these CCs ranged from 0.984 to 0.993 (mean CC = 0.990) for Factor 1, and from 0.906 to 0.960 (mean CC = 0.937) for Factor 2. The average of the CCs across the two factors was 0.963. In the three-factor model, on the other hand, CCs were much lower for two of the three factors; CCs ranged from 0.699 to 0.934 (mean CC = 0.825) for Factor 1, from 0.835 to 0.922 (mean CC = 0.888) for Factor 2, and from 0.915 to 0.951 (mean CC = 0.940) for Factor 3. Thus, a two-factor solution replicated across all three subsamples, whereas a three-factor solution did not.

Next, we examined the pattern of factor loadings (see three-factor and two-factor solutions for each sample in Supplementary Tables 2 and 3). As seen in Table 3, most items loaded onto one of the two factors with corresponding low cross-loadings.

The two-factor solution corresponded to Evans and Rothbart's (2008) analysis where HSPS Factor 1 was called "Negative Affect" and HSPS Factor 2 was called "Orienting Sensitivity." In contrast, as shown in Supplementary Table 2, in the three-factor model most items loaded inconsistently on factors when comparing across samples–many had low loadings for all factors and/or high-cross loadings between more than one factor. Thus, because both the CCs and pattern of factor loadings suggested that a two-factor solution was more optimal, we proceeded to use a two-factor solution, referred to as Negative Sensory Responsivity (NSR) and Positive Sensory Responsivity (PSR) in all subsequent analyses. We then calculated factor scores for NSR and PSR which were used in all analyses (i.e., we did not average items to create subscales).

Table 3
Exploratory factor analysis loadings for 2-factor model for full Study 1 sample.

HSPS item	NSR	PSR
1. Easily overwhelmed by sensory input?	**0.679**	0.024
2. Aware of environmental subtleties?	0.010	**0.530**
3. Others' moods affect you?	**0.421**	0.241
4. More sensitive to pain?	**0.498**	0.025
5. Need to withdraw during busy days?	**0.599**	0.031
6. Sensitive to caffeine?	0.341	0.093
7. Overwhelmed by lights, smells, sounds?	**0.635**	0.010
8. Have a rich, complex inner life?	−0.110	**0.565**
9. Uncomfortable with loud noises?	**0.637**	−0.006
10. Moved by the arts or music?	0.063	**0.585**
11. Nervous system feel frazzled sometimes?	**0.661**	0.075
12. Conscientious?	−0.006	**0.525**
13. Startle easily?	**0.584**	0.041
14. Get rattled when not enough time?	**0.712**	−0.017
15. Know how to make others more comfortable?	−0.030	**0.454**
16. Annoyed when have to do too many things?	**0.623**	−0.055
17. Try hard to avoid mistakes or forget things?	0.199	0.274
18. Avoid violent movies and TV?	0.332	−0.016
19. Become unpleasantly aroused when a lot is going on?	**0.686**	−0.050
20. Strong reaction to hunger?	**0.428**	0.071
21. Changes in life shake you up?	**0.638**	−0.012
22. Notice and enjoy delicate or fine scents, tastes, etc.?	0.016	**0.652**
23. Unpleasant to have a lot going on at once?	**0.758**	−0.139
24. High priority to avoid upsetting situations?	**0.542**	0.077
25. Bothered by intense stimuli?	**0.746**	−0.041
26. Become nervous when being observed?	**0.674**	−0.094
27. Parents or teachers see you as a sensitive or shy child?	**0.439**	−0.013

Note. Promax rotation. NSR = Negative Sensory Responsivity, PSR = Positive Sensory Responsivity, Bolded = one factor > 0.4 and the corresponding factor < 0.3.

3.2. Correlations between HSPS factors and Big Five traits

Zero-order correlations between the two HSPS Factor scores and personality traits were as follows: NSR with openness ($r = -0.12$, $p < .05$), agreeableness ($r = -0.19$, $p < .01$), extraversion ($r = -0.34$, $p < .01$), and neuroticism ($r = 0.61$, $p < .01$), and PSR with openness ($r = 0.46$, $p < .01$), agreeableness ($r = .18$, $p < .01$), extraversion ($r = 0.12$, $p < .01$), and neuroticism ($r = 0.09$, $p < .01$).

3.3. Positive interpersonal sensitivity

Zero-order correlations between positive interpersonal sensitivity variables and HSPS factors are shown in Table 4a (see Supplementary Table 4 for zero-order correlations between positive interpersonal sensitivity variables). For zero-order correlations between positive interpersonal sensitivity variables and Big Five traits, see Supplementary Table 5.

NSR was most strongly correlated with negative emotional contagion ($r = 0.4$, $p < .01$) and AQ Sociability ($r = 0.38$, $p < .01$; higher scores are indicative of decreased social functioning), with smaller positive associations with IRI-EC ($r = 0.12$, $p < .01$) and the BEES ($r = 0.11$, $p < .01$). PSR most strongly correlated with self-reported empathy such as the TEQ ($r = 0.44$, $p < .01$) and the EQ ($r = 0.43$, $p < .01$), and was positively associated with all other positive interpersonal sensitivity variables—except a negative correlation was found with AQ Sociability ($r = -0.16$, $p < .01$).

As shown in Supplementary Table 6, with the inclusion of neuroticism, agreeableness, and extraversion, hierarchical linear regression analyses showed that NSR was negatively associated with empathy and prosociality, and positively associated with constructs including negative emotional contagion and AQ Sociability and Mentalizing. PSR was positively associated with all positive interpersonal sensitivity variables coded in the positive direction, and negatively associated with all coded in the negative direction. The average β estimate for NSR was 0.113, the average β estimate for PSR was 0.241, and the average $R^2 = 0.069$. The

Table 4
Study 1 correlations between HSPS factors and interpersonal sensitivity variables across all samples.

a) Positive interpersonal sensitivity		
Variables	NSR	PSR
1. NSR	–	
2. PSR	0.310**	–
3. TEQ	0.031	0.442**
4. EQ	−0.106**	0.432**
5. AQ-M	0.100**	−0.440**
6. IRI-PT	−0.036	0.323**
7. IRI-EC	0.123**	0.386**
8. BEES	0.109**	0.390**
9. EC-Pos	0.048	0.339**
10. EC-Neg	0.395**	0.300**
11. Communion	0.030	0.340**
12. Prosociality	0.064*	0.176**
13. AQ-S	0.375**	−0.161**
b) Negative interpersonal sensitivity		
Variables	NSR	PSR
1. NSR	–	
2. PSR	0.310**	–
3. LSAS	0.525**	0.000
4. SIAS	0.551**	−0.050
5. SPS	0.534**	0.025
6. FNES	0.460**	0.097**
7. Dysphoria	0.479**	0.131**
8. IPSM	0.530**	0.238**
9. BIS	0.542**	0.189**
10. Sens to Rej.	0.357**	−0.080**
11. Rej. Sens.	0.398**	0.005
12. ECR-Anx	0.446**	0.126**
13. ECR-Avo	0.228**	−0.090**
14. ERS	0.644**	0.201**
15. IRI-PD	0.604**	−0.023
16. RSAS	−0.213**	0.129**
c) Social cognitive ability		
Variables	NSR	PSR
1. NSR	–	
2. PSR	0.310**	–
3. RMET	−0.008	0.214**
4. Emo Bio	0.048	0.112**

Note. *$p < .05$; **$p < .01$. NSR = HSPS Negative Sensory Responsivity factor, PSR = HSPS Positive Sensory Responsivity factor, *Positive Interpersonal Sensitivity:* TEQ = Toronto Empathy Questionnaire, EQ = Empathy Quotient short form; AQ-M = Mentalizing factor of the Autism Spectrum Quotient, IRI-PT = Interpersonal Reactivity Index-Perspective Taking subscale, IRI-EC = Interpersonal Reactivity Index Empathic Concern subscale, BEES = Brief Emotional Empathy Scale, EC-Pos = Emotional contagion for positive emotions, EC-Neg = Emotional contagion for negative emotions, Communion = Communion subscale of the Personal Attributes Questionnaire, Prosociality = Social Value Orientations Slider Scale measure of prosociality, AQ-S = Sociability factor of the Autism Spectrum Quotient. *Negative Interpersonal Sensitivity:* LSAS = Liebowitz Social Anxiety Scale, SIAS = Social Interaction Anxiety Scale, SPS = Social Phobia Scale, FNES = Brief Fear of Negative Evaluation Scale, Dysphoria = Inventory of Depression and Anxiety Symptoms-Dysphoria subscale, IPSM = Interpersonal Sensitivity Measure, BIS = Behavioral Inhibition System scale, Sens to Rej. = Mehrabian Sensitivity to Rejection Scale, Rej. Sens. = Adult Rejection Sensitivity Questionnaire, ECR-Anx = Experience in Close Relationships-Adult Attachment Anxiety subscale, ECR-Avo = Experience in Close Relationships-Adult Attachment Avoidance subscale, ERS = Emotional Reactivity Scale, IRI-PD = Interpersonal Reactivity Index-Personal Distress subscale, RSAS = Revised Social Anhedonia Scale – Short form, *Social Cognitive Ability:* RMET = Reading the Mind in the Eyes Test, Emo Bio = Emotion Perceptions of Biological Motion task.

most variance explained was in the prediction of AQ mentalizing (R^2 = 0.198), the Empathy Quotient (R^2 = 0.126), negative emotional contagion (R^2 = 0.093), and the Toronto Empathy Questionnaire (R^2 = 0.088). Supplementary Table 7 shows that the inclusion of openness in the subsample maintained nearly all results, but the average β estimates and variance explained were slightly reduced.

3.4. Negative interpersonal sensitivity

Table 4b shows zero-order correlations between negative interpersonal sensitivity variables and the HSPS factors (see Supplementary Table 4 for zero-order correlations between negative interpersonal sensitivity variables). For zero-order correlations between negative interpersonal sensitivity variables and Big Five traits, see Supplementary Table 5. NSR was most strongly correlated with emotional reactivity (r = 0.64, $p < .01$) and personal distress (r = 0.60, $p < .01$), with significant positive associations for all other variables ranging from r = 0.21 − 0.64. PSR was positively correlated with the interpersonal sensitivity measure (r = 0.24, $p < .01$), BIS (r = 0.19, $p < .01$), and emotional reactivity (r = 0.20, $p < .01$), in addition to other smaller associations.

Supplementary Table 6 shows the results of hierarchical linear regression analyses where both HSPS factors significantly predicted all negative interpersonal sensitivity constructs above and beyond neuroticism, agreeableness, and extraversion. The average β estimate for NSR was 0.261, the average β estimate for PSR was 0.08, and the average R^2 = 0.049. The most variance explained was in the prediction of the Personal Distress subscale of the IRI (R^2 = 0.136), the Social Phobia Scale (R^2 = 0.086), the Emotional Reactivity Scale (R^2 = 0.064), and the Liebowitz Social Anxiety Scale (R^2 = 0.063). Supplementary Table 7 shows that the pattern of associations remained similar when including openness, with slight reductions to the average β estimates and variance explained.

3.5. Social cognitive ability

Zero-order correlations between social cognitive ability variables and HSPS factors are shown in Table 4c (see Supplementary Table 4 for zero-order correlations between social cognitive ability variables). For zero-order correlations between social cognitive ability variables and Big Five traits, see Supplementary Table 5. NSR was not correlated with either behavioral task, but PSR was positively associated with RMET (r = 0.21, $p < .01$) and emotion perceptions of biological motion (r = 0.11, $p < .01$). The bottom of Supplementary Table 6 shows the results of hierarchical linear regression analyses. Whereas both HSPS factors significantly predicted RMET scores above and beyond neuroticism, agreeableness, and extraversion (NSR β = −0.201, PSR β = 0.252, R^2 = 0.058), only PSR significantly predicted the total score for the emotion perceptions of biological motion (β = 0.099, R^2 = 0.009). With the addition of openness, only NSR significantly predicted RMET scores (β = −0.201, R^2 = 0.026) and neither HSPS factor predicted emotion perceptions of biological motion (Supplementary Table 7).

4. Study 2

4.1. Method

4.1.1. Open science

This study was not preregistered. Full information about the study materials and methods can be found at https://osf.io/pfst6. Data is publicly available: https://osf.io/9v6wh/.

4.1.2. Participants

The initial set of participants were recruited between January 2018 and October 2019 from SMU (n = 563) and Amazon's Mechanical Turk (MTurk; n = 745) and completed several measures including online surveys.

4.1.3. MTurk data collection and data cleaning procedure

MTurk workers were at least 18 years old, had ≥90% HIT approval rate, ≥ 50 HITs approved, and they had to be in the United States. We initially recruited 120 participants spanning July through November 2019 and paid $3. However, following the report by Chmielewski and Kucker (2020) identifying low quality data on MTurk during this time

frame, and expressing concerns with traditional attention check self-report items, we made several changes based on their recommendations including: adding open-ended questions, and using CloudResearch to block duplicate IP addresses, suspicious Geocode locations, and MTurk IDs from their Universal Exclude List. We also raised our payment to $5. We then recruited an additional 996 participants. Because the study remained open until all participants had submitted their results, data from 45 additional participants were also recorded. This resulted in 1161 total participants. We identified non-human (i.e., "bots"), and dishonest human (i.e., "farmers") participants by including open-ended questions following two videos that had been used for a study unrelated to the present investigation.

A co-author reviewed all responses to open-ended questions (there was one general question and three that followed videos unrelated to the present study) and flagged any potential "bot-based/farmer" responding. Participants with answers that were irrelevant to the question or to the video (e.g., "the topic was very useful for us," "nice and good survey," "very good speech"), markedly ungrammatical or non-sensical (e.g., "good behaviour was that person," "it was problem has taken at the past"), or obviously copy-and-pasted were identified as "problematic" and all other participants were classified as "acceptable." A subset of 50 participants did not have responses to the open-ended questions: some simply did not respond to any of them, and a small number of participants completed the survey prior to the addition of the open-ended questions. Based on acceptable internal consistency estimates for the Big Five traits for the subsample with no answers (all αs $>$ 0.80 except agreeableness, $\alpha = 0.66$), they were also included in the final dataset.

Out of 1,161 participants, 414 participants were removed and 747 retained. For each group, cronbach's alpha was obtained for the Big Five Inventory scales (BFI; John et al., 1991). Based on Chmielewski and Kucker (2020), internal consistency estimates of the BFI are typically in the mid 0.80 s for MTurk samples. Internal consistency estimates for the subsample that was removed ranged between −0.09 and 0.51, whereas the participants who were retained showed estimates from 0.80 to 0.87. Last, two duplicate cases were removed from the dataset, resulting in a final sample of 745 participants. For both these participants, the entry from the later timepoint was removed to avoid practice effects.

We did not employ this technique among the SMU sample since all participants completed the study with an experimenter present. In total, 1308 participants across the SMU and MTurk samples remained; however, factor scores for 68 people were not computed due to one or more missing items on the HSPS. Thus, the final sample included 1240 participants (53% female; age range = 18–80 years, *M* age = 30.02, *SD* = 12.21, *M* SES = 47.28, *SD* = 12.76; one participant did not report their gender, two participants identified as Nonbinary, and one participant did not report their racial/ethnic identification) who self-identified as White (76.5%), Black or African-American (11%), Asian (8.9%), Native American or Alaska Native (1.2%) and Other (2.3%). MTurk participants were awarded monetary compensation, and college students were awarded research credit for participation. The studies were approved by the Southern Methodist University Institutional Review Board, and informed consent was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki.

4.1.4. Measures

4.1.4.1. Self-report measures. Environmental sensitivity. As in Study 1, environmental sensitivity was measured with the HSPS (Aron & Aron, 1997), and two factor scores (NSR and PSR) were created.

Personality traits. Personality traits were once again measured using the Big Five Inventory (BFI; John & Srivastava, 1999) and included agreeableness ($\alpha = 0.80$, $n = 1233$), extraversion ($\alpha = 0.87$, $n = 1234$), openness ($\alpha = 0.81$, $n = 1233$), neuroticism ($\alpha = 0.86$, $n = 1233$), and conscientiousness ($\alpha = 0.85$, $n = 1233$).

Positive interpersonal sensitivity related variables. A subset of the same variables used in Study 1 were used in Study 2 including the TEQ (Spreng et al., 2009), short form EQ (Wakabayashi et al., 2006), Perspective Taking and Empathic Concern subscales from the IRI (Davis, 1980), the BEES (Mehrabian, 1996), the ECS (Doherty, 1997), the Mentalizing factor (Palmer et al., 2015) of the AQ (Baron-Cohen, Wheelwright, Skinner, et al., 2001), the communion subscale of the PAQ (Spence et al., 1975), and the Sociability factor (Palmer et al., 2015) of the AQ (Baron-Cohen, Wheelwright, Skinner, et al., 2001). Means, standard deviations, and reliability estimates are displayed in Supplementary Table 8.

Negative interpersonal sensitivity related variables. A subset of measures from Study 1 were used in Study 2 including the SPS (Mattick et al., 1998), the SIAS (Mattick et al., 1998), the LSAS (Liebowitz, 1987), the Dysphoria subscale from the IDAS-II (Watson et al., 2012), the A-RSQ (Berenson et al., 2009), the Interpersonal Sensitivity Measure (Boyce & Parker, 1989), the Rejection Sensitivity- Adult Questionnaire (ARSQ; Berenson et al., 2009), a modified 18-item version (Carmichael & Reis, 2005) of the ECR scale (Fraley et al., 2000), the Emotional Reactivity Scale (Nock et al., 2008), the Personal Distress subscale of the IRI (Davis, 1980), and the Revised Social Anhedonia Scale (Winterstein et al., 2011). Means, standard deviations, and reliability estimates are displayed in Supplementary Table 8.

Socioeconomic Status. As in Study 1, participants completed the Barratt simplified measure of social status (Barratt, 2006).

Behavioral measures of social cognitive ability. As in Study 1, participants completed the Emotion Perceptions of Biological Motion Task (Heberlein et al., 2004) and the RMET (Baron-Cohen, Wheelwright, Hill, et al., 2001), although in Study 2 a brief version was used (Olderbak et al., 2015). The scoring method that was used for Study 1 was also used for Study 2.

4.1.5. Procedure

Participants completed questionnaires and behavioral measures (as well as other unrelated questionnaires) online via Qualtrics (Provo, UT).

Table 5
Principal axis factor loadings for 2-factors across samples.

HSPS item	NSR	PSR
1. Easily overwhelmed by sensory input?	**0.722**	0.007
2. Aware of environmental subtleties?	0.037	**0.603**
3. Others' moods affect you?	0.324	0.390
4. More sensitive to pain?	**0.578**	−0.048
5. Need to withdraw during busy days?	**0.644**	0.072
6. Sensitive to caffeine?	**0.559**	−0.012
7. Overwhelmed by lights, smells, sounds?	**0.774**	−0.055
8. Have a rich, complex inner life?	−0.042	**0.534**
9. Uncomfortable with loud noises?	**0.727**	−0.022
10. Moved by the arts or music?	−0.046	**0.696**
11. Nervous system feel frazzled sometimes?	**0.720**	0.076
12. Conscientious?	−0.041	**0.569**
13. Startle easily?	**0.690**	0.028
14. Get rattled when not enough time?	**0.686**	0.051
15. Know how to make others more comfortable?	0.005	**0.555**
16. Annoyed when have to do too many things?	**0.543**	0.089
17. Try hard to avoid mistakes or forget things?	0.205	0.364
18. Avoid violent movies and TV?	**0.417**	−0.002
19. Become unpleasantly aroused when a lot is going on?	**0.753**	−0.061
20. Strong reaction to hunger?	**0.508**	0.054
21. Changes in life shake you up?	**0.699**	0.015
22. Notice and enjoy delicate or fine scents, tastes, etc.?	−0.067	**0.741**
23. Unpleasant to have a lot going on at once?	**0.729**	−0.032
24. High priority to avoid upsetting situations?	**0.528**	0.129
25. Bothered by intense stimuli?	**0.828**	−0.114
26. Become nervous when being observed?	**0.744**	−0.110
27. Parents or teachers see you as a sensitive or shy child?	**0.530**	0.065

Note. Promax rotation. Bolded = one factor $>$ 0.4 and the corresponding factor $<$ 0.3.

4.1.6. Statistical analyses

Based on the exploratory factor analysis conducted in Study 1, we used the same technique to compute the two HSPS factor scores (see Table 5 for factor loadings).

We then examined the zero-order correlations of each HSPS factor with positive and negative interpersonal sensitivity, as well as social cognitive ability. Next, as in Study 1, we conducted hierarchical linear regression analysis (using SPSS v. 24) with all Big Five personality traits in Block 1, and both HSPS factors as predictors of each measure of interpersonal sensitivity in Block 2.

5. Results

5.1. Correlations between HSPS factors and Big Five traits

Zero-order correlations between the two HSPS factor scores and personality traits were as follows: NSR with openness ($r = -0.03$, $p = .33$), agreeableness ($r = -0.25$, $p < .01$), extraversion ($r = -0.24$, $p < .01$), neuroticism ($r = 0.59$, $p < .01$), and conscientiousness ($r = -0.32$, $p < .01$), and PSR with openness ($r = 0.47$, $p < .01$), agreeableness ($r = 0.14$, $p < .01$), extraversion ($r = 0.01$, $p = .85$), neuroticism ($r = 0.14$, $p < .01$), and conscientiousness ($r = 0.13$, $p < .01$). Thus, the pattern and magnitude of associations between HSPS factors and Big Five traits were similar in Study 1 and Study 2.

5.2. Positive interpersonal sensitivity

Zero-order correlations between positive interpersonal sensitivity variables and HSPS factors are shown in Table 6a (see Supplementary Table 9 for zero-order correlations between positive interpersonal sensitivity variables). For zero-order correlations between positive interpersonal sensitivity variables and Big Five traits, see Supplementary Table 10.

NSR was most strongly correlated with negative emotional contagion ($r = 0.40$, $p < .01$) and AQ Sociability ($r = 0.35$, $p < .01$; higher scores are indicative of decreased social functioning), with smaller positive associations with BEES ($r = 0.2$, $p < .01$) and AQ Mentalizing ($r = 0.15$, $p < .01$; higher scores represent lower perceived mentalizing ability). PSR most strongly correlated with the EQ ($r = 0.44$, $p < .01$), communion ($r = 0.43$, $p < .01$), TEQ ($r = 0.38$, $p < .01$), negative emotional contagion ($r = 0.38$, $p < .01$), and positive emotional contagion ($r = 0.36$, $p < .01$).

As shown in Supplementary Table 11, and as in Study 1, after including all Big Five traits, hierarchical linear regression analyses showed that NSR was negatively associated with positive interpersonal sensitivity constructs, whereas PSR was positively associated with all positive interpersonal sensitivity variables coded in the positive direction, and negatively associated with variables coded in the negative direction.

The average β estimate for NSR was 0.087, the average β estimate for PSR was 0.164, and the average $R^2 = 0.03$. Thus, slightly lower average β estimates were found for Study 2 compared to Study 1. Unique variance was explained for nearly all positive interpersonal sensitivity variables across both samples with the most variance explained in the prediction of negative emotional contagion ($R^2 = 0.095$), the EQ ($R^2 = 0.049$), positive emotional contagion ($R^2 = 0.048$), and communion ($R^2 = 0.043$).

5.3. Negative interpersonal sensitivity

Zero-order correlations between negative interpersonal sensitivity variables and HSPS factors are shown in Table 6b (see Supplementary Table 9 for zero-order correlations between negative interpersonal sensitivity variables). For zero-order correlations between positive interpersonal sensitivity variables and Big Five traits, see Supplementary Table 10. As in Study 1, NSR was significantly associated with all negative interpersonal sensitivity measures, with the strongest associations found with the social anxiety scales ($rs = 0.61$-0.62, $ps < 0.01$) and dysphoria ($r = 0.59$, $ps < 0.01$). PSR was most strongly associated with the interpersonal sensitivity measure ($r = 0.28$, $p < .01$) in the SMU sample, with other positive associations including dysphoria ($r = 0.22$, $p < .01$), and the social anxiety scales ($rs = 0.11$-0.18, $ps < 0.01$)

Supplementary Table 11 shows the results of hierarchical linear regression analyses where both HSPS factors significantly predicted all negative interpersonal sensitivity constructs above and beyond all Big Five traits. The average β estimate for NSR was 0.278, the average β estimate for PSR was 0.075, and the average $R^2 = 0.066$. These results were very similar to those reported in Study 1. With the most variance

Table 6
Study 2 correlations between HSPS factors and interpersonal sensitivity variables.

a) Positive interpersonal sensitivity		
Variables	NSR	PSR
1. NSR	–	
2. PSR	0.436**	–
3. TEQ	0.078	0.381**
4. EQ	−0.037	0.444**
5. AQ-M	0.153**	−0.356**
6. IRI-PT	−0.090**	0.313**
7. IRI-EC	−0.019	0.324**
8. BEES	0.196**	0.357**
9. EC-Pos	0.006	0.355**
10. EC-Neg	0.401**	0.377**
11. Communion	0.103*	0.427**
12. AQ-S	0.352**	−0.019
b) Negative interpersonal sensitivity		
Variables	NSR	PSR
1. NSR	–	
2. PSR	0.436**	–
3. LSAS	0.611**	0.183**
4. SIAS	0.606**	0.110**
5. SPS	0.621**	0.162**
6. Dysphoria	0.590**	0.218**
7. IPSM	0.458**	0.275**
8. Rej. Sens.	0.319**	−0.050
9. ECR-Anx	0.414**	0.147**
10. ECR-Avo	0.195**	−0.079
11. ERS	0.504**	0.177**
12. IRI-PD	0.583**	0.069*
13. RSAS	0.298**	−0.047
c) Social cognitive ability		
Variables	NSR	PSR
1. NSR	–	
2. PSR	0.348**	–
3. RMET	−0.030	0.172**
4. Emo Bio	0.042	0.182**

Note. *$p < .05$; **$p < .01$. NSR = Negative Sensory Responsivity, PSR = Positive Sensory Responsivity, *Positive Interpersonal Sensitivity:* TEQ = Toronto Empathy Questionnaire, EQ = Empathy Quotient short form; AQ-M = Mentalizing factor of the Autism Spectrum Quotient, IRI-PT = Interpersonal Reactivity Index-Perspective Taking subscale, IRI-EC = Interpersonal Reactivity Index Empathic Concern subscale, BEES = Brief Emotional Empathy Scale, EC-Pos = Emotional contagion for positive emotions, EC-Neg = Emotional contagion for negative emotions, Communion = Communion subscale of the Personal Attributes Questionnaire, AQ-S = Sociability factor of the Autism Spectrum Quotient. *Negative Interpersonal Sensitivity:* LSAS = Liebowitz Social Anxiety Scale, SIAS = Social Interaction Anxiety Scale, SPS = Social Phobia Scale, Dysphoria = Inventory of Depression and Anxiety Symptoms-Dysphoria subscale, IPSM = Interpersonal Sensitivity Measure, Rej. Sens. = Adult Rejection Sensitivity Questionnaire, ECR-Anx = Experience in Close Relationships-Adult Attachment Anxiety subscale, ECR-Avo = Experience in Close Relationships-Adult Attachment Avoidance subscale, ERS = Emotional Reactivity Scale, IRI-PD = Interpersonal Reactivity Index-Personal Distress subscale, RSAS = Revised Social Anhedonia Scale – Short form, *Social Cognitive Ability:* RMET = Reading the Mind in the Eyes Test, Emo Bio = Emotion Perceptions of Biological Motion task.

explained in the prediction of the Social Phobia Scale ($R^2 = 0.161$), the Liebowitz Social Anxiety Scale ($R^2 = 0.148$), the Personal Distress subscale of the IRI ($R^2 = 0.105$), and the Social Interaction Anxiety Scale ($R^2 = 0.093$).

5.4. Social cognitive ability

Zero-order correlations between the RMET (M = 0.82, SD = 0.07) and emotion perceptions of biological motion task (M = 0.76, SD = 0.15) and HSPS factors are shown in Table 6c (see Supplementary Table 9 for zero-order correlations between social cognitive ability variables). For zero-order correlations between social cognitive ability variables and Big Five traits, see Supplementary Table 10. NSR was not correlated with either behavioral task, but PSR was positively associated with RMET ($r = 0.17, p < .01$) and the emotion perceptions of biological motions task ($r = 0.18, p < .01$). The bottom of Supplementary Table 11 shows the results of hierarchical linear regression analyses. Whereas both HSPS factors significantly predicted scores on the RMET short above and beyond all Big Five personality traits (NSR $\beta = -0.198$; PSR $\beta = 0.286$, $R^2 = 0.048$), only PSR significantly predicted the total score for the emotion perceptions of biological motion ($\beta = 0.19$, $R^2 = 0.02$). These results differed from Study 1 where only NSR significantly predicted RMET performance, and neither HSPS factor predicted performance on the emotion perceptions of biological motion task.

5.5. Internal meta-analysis

To examine the combined effect sizes of the NSR and PSR factors on constructs related to interpersonal sensitivity, we conducted a random-effects internal *meta*-analysis across Study 1 and Study 2 using the Meta-Essentials tool (Suurmond et al., 2017). The average combined effect size of the association between PSR and constructs related to positive interpersonal sensitivity was $sr = 0.19$ (for full results see Supplementary Table 12). Similarly, the average combined effect size for NSR and constructs related to negative interpersonal sensitivity was $sr = 0.20$. The average combined effect size for social cognitive ability was $sr = 0.08$ for NSR and $sr = 0.16$ for PSR. In examining the effects of NSR and PSR on RMET accuracy above and beyond Big Five traits across Study 1 and 2, significant effects were found for NSR, $sr = -0.15$, $p < .01$ and PSR, $sr = 0.22$, $p < .01$. However, since the full version of the RMET was used in Study 1 and a short version of the RMET was used in Study 2, these estimates should be interpreted with caution. NSR had a significant effect of $sr = -0.01$, $p < .01$, and PSR had a significant effect of $sr = 0.10$, $p < .01$ on the emotion perceptions of biological motion task. Importantly, to maximize the sample size, we relied on the Study 1 analyses that included agreeableness, extraversion, and neuroticism whereas Study 2 included all Big Five traits. Thus, differences in predictors between studies contributed to increased error in computing the estimated combined effect sizes.

6. Discussion

Environmental sensitivity, as measured by the Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997), is intended to be a self-report indexing differential susceptibility to the environment (Belsky & Pluess, 2009; Greven et al., 2019). It therefore follows that people who are more environmentally sensitive should also show higher levels of interpersonal sensitivity. Since there is no agreed upon definition of interpersonal sensitivity, in the present paper, we sought to characterize interpersonal sensitivity by including constructs related to three broad domains: positive interpersonal sensitivity (e.g., cognitive empathy, affective empathy, affiliation), negative interpersonal sensitivity (e.g., social anxiety, depression, rejection sensitivity), and social cognitive ability (emotion recognition and theory of mind). Although previous studies, including a *meta*-analysis, have shown associations between environmental sensitivity and personality traits including neuroticism and openness (Bröhl et al., 2020; Lionetti et al., 2019), a recent study found that environmental sensitivity may be entirely accounted for by the measurement of Big Five personality traits, and does not predict at least one factor related to interpersonal sensitivity (emotion recognition) above and beyond Big Five traits (Hellwig & Roth, 2021). The present study builds on this recent finding by examining the unique contribution of environmental sensitivity on constructs related to three broad dimensions of interpersonal sensitivity above and beyond Big Five traits. In contrast to Hellwig and Roth (2021), we found several associations when including two HSPS factors, Negative Sensory Responsivity (NSR) and Positive Sensory Responsivity (PSR), as predictors.

After an analysis of the coefficients of congruence (Tucker, 1951) using three different samples from Study 1, we determined that a two-factor solution for the HSPS scale would be the most optimal. The resulting NSR and PSR factors are nearly identical to those identified as "Negative Affect" and "Orienting Sensitivity" in a previous study (Evans & Rothbart, 2008). Indeed, to further examine the association between NSR and PSR and previous research, we calculated scores in both studies for "Negative Affect" and "Orienting Sensitivity" based on Evans and Rothbart (2008) and found that NSR was correlated $r > 0.98$ with "Negative Affect" and PSR was correlated $r > 0.89$ with "Orienting Sensitivity." We also examined the correlation between NSR and PSR and a three-factor solution for the HSPS (Smolewska et al., 2006), with NSR correlated $r > 0.93$ with "Ease of Excitation" and $r > 0.84$ with "Low Sensory Threshold," and PSR correlated $r > 0.95$ with "Aesthetic Sensitivity." Thus, as in the two-factor model identified by Evans and Rothbart (2008), our two-factor model includes one factor (NSR) which represents a combination of the Ease of Excitation and Low Sensory Threshold models (Smolewska et al., 2006). Our PSR factor maps onto "Orienting Sensitivity" (Evans and Rothbart, 2008) or "Aesthetic Sensitivity" (Smolewska et al., 2006). In addition, when examining the NSR factor, we found that it was highly correlated with the HSPS total score, as well as the newly developed short form HSP-12 total score (Pluess et al., 2020) ($rs > 0.90$). Thus, our approach was to examine the HSPS with a two-factor solution.

Results from Studies 1 and 2 demonstrated that the two-factors of the HSPS generally predicted constructs related to positive and negative interpersonal sensitivity, as well as behaviorally assessed social cognitive ability, in a construct-congruent manner. Specifically, NSR, which has been previously described as "Negative Affectivity" (Evans & Rothbart, 2008), was positively associated with constructs related to negative interpersonal sensitivity, whereas PSR, previously referred to as "Orienting Sensitivity" (Evans & Rothbart, 2008), was positively associated with constructs related to positive interpersonal sensitivity and social cognitive ability domains. In addition, on several occasions, NSR and PSR were both positively associated interpersonal sensitivity constructs such as emotional contagion for negative emotions, emotional reactivity, the Interpersonal Sensitivity Measure, and dysphoria. This pattern of results is in line with previous research showing that emotional contagion for negative emotions can be both beneficial or detrimental for social relationships (Murphy et al., 2018). Specifically, emotional reactivity has been related to positive interpersonal sensitivity in the form of empathic concern (Eisenberg et al., 1994), and contextual factors such as reduced social support have been associated with greater depression symptoms in individuals with higher levels of empathy (Sommerlad et al., 2021). Future studies are needed that examine subscales of the Interpersonal Sensitivity Measure (Boyce & Parker, 1989) to determine what facets of the total score may be related to both HSPS factors.

Interestingly, compared to positive and negative interpersonal sensitivity constructs, there was less consistency across studies when examining associations between HSPS factors and the behavioral assessments of social cognitive ability. Specifically, with the inclusion of all Big Five traits except conscientiousness, only NSR significantly predicted RMET scores in Study 1, and neither HSPS factor was associated with emotion perceptions of biological motion. In contrast, in a Study 2

subsample, with the inclusion of all Big Five traits, both HSPS factors significantly predicted RMET accuracy, and PSR was significantly associated with accuracy on the emotion perceptions of biological motion. Thus, based on the separate analyses conducted in Study 1 and Study 2, the relation between NSR and RMET performance was the most robust association across both studies. There are several potential explanations for these discrepancies between findings from Study 1 and Study 2. First, results changed with the inclusion of openness in Study 1, and then again with the inclusion of conscientiousness in Study 2. Second, Study 1 included the full version of the RMET whereas Study 2 included a brief version. The two different RMET versions are strongly but not perfectly correlated ($r > 0.7$; Olderbak et al., 2015). In addition, the Study 1 sample that completed the full RMET and biological motion task was much larger than the small subsample who completed the RMET short version and biological motion task in Study 2. Third, the type of behavioral task may be relevant as each measures a specific aspect of social cognition, or sub-domain of social cognition using different formats and types of stimuli (e.g., short video clips vs. static images). Fourth, like many behavioral or performance tasks (Patrick & Hajcak, 2016), there is limited data on the psychometric properties of the RMET. Indeed, high levels of error in measures may lead to replication failures (Chmielewski et al., 2016). Nonetheless, because Hellwig and Roth (2021) recently found no association between the three-factor model of HSPS and social cognitive ability in the form of emotion recognition, future research is needed to replicate these findings and further determine the extent to which HSPS factors may be related to behavioral assessments of social cognition.

6.1. Study strengths and limitations

Strengths of the current study include: 1) two studies with large sample sizes across three different sites (total $N = 2{,}617$), 2) a direct replication, 3) moving beyond examining associations of environmental sensitivity with Big Five personality traits and investigating unique associations of environmental sensitivity above and beyond the Big Five, 4) the use of several constructs related to three broad domains of interpersonal sensitivity, and 5) the use of two different behavioral measures of social cognitive ability. In addition to the study strengths, several limitations must also be noted including the reliance on a majority White and female sample based in the United States, the use of a cross-sectional correlational design, and the inclusion of all Big Five traits in only a subsample of participants when examining associations with social cognitive ability. Future studies are needed to determine whether the present findings can be replicated in more diverse populations. In addition, future studies would benefit from examining how positive and negative childhood experiences may moderate the associations that were found in the present study, as previous studies have reported moderating effects (Acevedo et al., 2017; Liss et al., 2005).

6.2. Conclusion

In sum, the present study shows that environmental sensitivity, as measured by the HSPS, contributes to the prediction of unique variance in constructs related to interpersonal sensitivities above and beyond Big Five traits. Future research would benefit from the examination of biological mechanisms that may underly the relationship between environmental sensitivity and interpersonal sensitivity, such as neuroendocrine responses to social stressors (e.g., the Trier Social Stress Test; Kirschbaum et al., 1993). The present results suggest that researchers who have an interest in understanding individual differences in sensitivity or reactivity to the social environment may wish to consider a measure of environmental sensitivity.

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Declaration of Competing Interest

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

Appendix A. Supplementary material

Supplementary material for this article can be found online at https://doi.org/10.1016/j.jrp.2022.104210.

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