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An investigation testing the perceptual advantage of Sensory Processing Sensitivity and its associations with the Big Five personality traits.

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Highlights:

- Sensory Processing Sensitivity (SPS) predicts the detection and identification of visually degraded stimuli.
- Individuals high in SPS may have low perceptual thresholds.
- SPS has associations with but is separable from the Big Five (neuroticism, openness, and extraversion).
- The perceptual advantage of high SPS may balance reactivity disadvantages in humans and other animals.

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Abstract:

This study investigated whether sensory processing sensitivity (SPS) is associated with a perceptual advantage, above just heightened brain, emotional and behavioural reactivity. Participants (N = 222) were tested on detection and identification of visually degraded words at three levels of difficulty, and completed the Highly Sensitive Person Scale (HSPS) and the Big Five Inventory. The positive subscale of the HSPS predicted both the detection and identification of visually degraded stimuli, beyond the Big Five traits. This contradicts claims that SPS is solely a combination of Big Five traits. Importantly, the perceptual advantage for highly sensitives may balance the disadvantages of being easily overwhelmed by stimuli and indicates separate evolutionary advantages and strategies for high and low SPS humans and other mammals.

Keywords:

Sensory Processing Sensitivity, Highly Sensitive Person, Highly Sensitive Person Scale, Big Five, Perceptual ability.

1. Introduction

Sensory processing sensitivity (SPS) is a temperament and biopsychological trait that leads to an increased sensory awareness, empathy, ease of overstimulation, and creativity, and is characterised by an enhanced depth of processing and awareness of subtleties (Aron & Aron, 1997; Aron, 2010; Greven et al., 2019). Designed to measure SPS, the Highly Sensitive Person Scale (HSPS) was established by Aron and Aron (1997). Subsequent research has shown different dimensions to this scale which describe positive and negative aspects of high SPS. For instance, Smolewska, McCabe, & Woody (2006) identified three subscales; Ease of Excitation (EOE) which refers to becoming overwhelmed by internal and external processes, Low Sensory Threshold (LST), defined by items referring to arousal in response to environmental surroundings, and Aesthetic Sensitivity (AES), which relates to an awareness and processing of subtleties and aesthetics in the environment. Although the subscales are intercorrelated, they represent different aspects of sensitivity. AES, which is a positive sensitivity, is thought to be conceptually distinct from LST and EOE, which are negative sensitivities (Liss, Mailloux, and Erchull, 2008; Sobocko & Zelenski, 2015; Vander Elst et al., 2019). Further research has confirmed a bifactor organisation of the HSPS. The first factor being total HSPS score (Aron & Aron, 1997), and the second these the three individual subscales (Smolewska et al., 2006).

1.1. Sensory Processing Sensitivity and the Big Five traits

Although characterised by Aron and colleagues as a personality measure distinct from other traits, including the Big Five (BF) traits (Costa & McCrae, 1992; McCrae & John, 1992; John & Srivastava, 1999), there have recently been claims that SPS is inseparable from neuroticism, openness to experience, and introversion due to the overlap and inconsistencies in definitions, behavioural outcomes, and previously found strong associations (Hellwig & Roth, 2021). For example, SPS is characterised by an aversion of negativity, enhanced processing of emotional events, and experience of stress, thus overlapping with neuroticism (Aron & Aron, 1997; Benham, 2006; Grimen & Diseth, 2016; Redfearn, van Ittersum, & Stenmark, 2020; Yano, Kase, & Oishi. 2019). Furthermore, openness to experience is closely linked to AES, with similarities in creative behaviours and appreciation of aesthetic experiences (Aron & Aron, 1997; Aron, 2010; Bridges & Schendan, 2019; Smolewska et al., 2006). Extending this to facets, Bröhl et al. (2020) demonstrated associations between AES with the openness facets of aesthetics, ideas and fantasy as measured by the NEO-PI-3 (McCrae et al., 2005), as well as associations with the neuroticism facets of anxiety, depression, vulnerability, and self-consciousness with EOE and LST.

On the other hand, the evidence to suggest a clear relationship between SPS and introversion is limited. For instance, although there are similarities between the behaviours of introverts and highly sensitive persons (HSPs), HSPs may simply be more likely to possess introverted behaviours due to their enhanced processing and awareness of social stimuli. Furthermore, whereas negative correlations between extraversion and EOE and LST have been demonstrated previously, such as in Grimen and Diseth (2016) and Yano et al. (2019), a meta-analysis revealed no relationship between SPS and introversion, conscientiousness, or agreeableness (Lionetti et al., 2019), Thus, the evidence for a link between SPS and introversion is weak, and it is thought that an estimated 30% of HSPs are extraverted (Aron, 2010).

Exploring the distinguishability of SPS from existing personality traits, Hellwig and Roth (2021) conducted two studies using the NEO PI-R and German HSPS (Konrad & Herzberg, 2019). Confirmatory factor analysis, with three models to estimate latent variable correlations between the subscales of HSPS and the Big Five, found a high correlation between EOE and neuroticism, a negative correlation between EOE and extraversion, and a correlation of near one between AES and openness to experience. From these results, they summarise that LST is the only element of SPS that is distinct from pre-existing personality traits, although it could be a mix of neuroticism and extraversion. Study two replicated these findings, and their overall conclusion was that the "…empirical basis for SPS is currently weak" (p. 10) and that SPS is not an entirely new personality construct. The authors also demonstrated that the emotional recognition ability of HSP can be fully accounted for by the BF, and their study found "no evidence that SPS can be viewed as an ability to process stimuli" (p. 9).

To extend these findings, Tabak et al. (2022) conducted a two-part study to explore the associations between the HSPS, the BF, and measures relating to interpersonal sensitivity. A two-component solution to the HSPS was found, labelled as Positive Sensory Responsivity (PSR) and Negative Sensory Responsivity (NSR). The 19-item NSR represents a combined factor of EOE and LST, but with the exclusion of items 3 ("Do other people's moods affect you?") and 17 ("Do you try hard to avoid making mistakes or forgetting things?") due to low factor loadings. PSR is a 6-item subscale, with all items belonging to AES, except for item 5 ("Do you find yourself needing to withdraw during busy days, into bed or into a darkened room or any place where you can have some privacy and relief from stimulation?"), which loaded onto NSR. Item 5 describes the experience of overstimulation, namely reducing such stimulation by withdrawing, thus not fitting with the "aesthetic awareness" account of AES, and perhaps corresponding more to the negative facets of SPS (i.e., NSR). Contrary to the findings of Hellwig and Roth (2021), only moderately sized correlations were found between these subscales and the BF traits, particularly between NSR and introversion and neuroticism, and PSR and openness to experience. Also, further critiquing Hellwig and Roth (2021), Tabak et al. (2022) found that PSR and NSR predicted emotional recognition beyond the BF traits, particularly those relating to interpersonal processes (neuroticism, agreeableness, and extraversion). Once openness was added to the model, only NSR was a significant predictor. This suggests that SPS, as captured by the HSPS, is an ability construct and is separable from the BF traits.

In addition, Gerstenberg (2012) found the subscales of the HSPS negatively correlated with reaction times, and EOE and LST correlated with reduced error rates during a visual detection task, while controlling for the BF. Neuroticism and extraversion were negatively and positively (respectively) associated with reaction times. Also, individuals with high LST experienced increases in stress from before to after participating, no such difference was found for any of the other personality traits or subscales of the HSPS. Therefore, this suggests that HSPs are less prone to errors during a visual task and are quicker at responding, posing implications on how they view the world. Also, the lack of relationship between error rates and the BF, specifically neuroticism, extraversion, and openness, indicates that SPS (as measured by the HSPS) is a separable construct.

1.2. Sensory Processing Sensitivity and perception

SPS has been previously associated with a perceptual advantage, suggesting it is an ability construct, contrary to the conclusions of Hellwig and Roth (2021). SPS is characterised by an enhanced depth of processing, that is the ability to perceive and process sensory information more deeply (Aron & Aron, 1997; Acevedo, Santander, Marhenke, Aron, & Aron, 2021; Lionetti et al., 2018), although this is thought to not concern the sense organs directly, but rather the way in which information is transmitted, interpreted, and responded to by the brain (Aron & Aron, 1997). Research has specifically suggested that SPS is associated with increased attentional and perceptual awareness of subtleties within the environment, including emotionally valenced stimuli, as mentioned previously.

Addressing possible mechanisms for this perceptual advantage of SPS, HSPs have been shown to take longer to respond to minor versus major changes to scenes during a change detection task, accompanied by increased brain activation in the visual and attention areas of the brain, including medial and posterior parietal regions, temporal regions, and the occipital lobe (Jagiellowicz et al., 2011). SPS has been further implicated in increased activations of brain regions involved in visual, attention, and reward processing, as well as self-reflection and empathy (Acevedo et al., 2014; Acevedo et al., 2017; Acevedo et al., 2018; Naumann et al., 2021).

Extending the work on perception, a novel area of perceptual experiences that has recently been addressed in the SPS literature is the response to ambiguous or degraded stimuli. Williams, Carr and Blagrove (2021) presented participants with Diana Deutsch's Phantom Word Illusion (Deutsch, 2003; 2019). Two performance measures were captured, the number of illusory words and the number of real words reported by participants. No associations were found for SPS and perception of illusory words, revealing a lack of evidence of HSP's susceptibility to perceptual illusions. There was, however, a correlation between HSPS score and the number of real words heard, that is, those who scored higher on the HSPS detected more true, degraded words within the random sounds, which provides evidence that HSPs are objectively more aware of subtleties within their environment.

Furthermore, Williams and Blagrove (2022) were first to test this perceptual advantage while differentiating between detection and identification. The authors replicated a study (Nees & Phillips, 2015) to test the perception of words within noise. Participants were presented with four types of audio recordings, with some containing speech that had been audibly degraded, as well as examples of pareidolia. They were instructed to state whether or not they heard a voice within the recording (detection), and, if they did, to identify what it had spoken (identification). Total SPS score was not related to the ability to detect or accurately identify real spoken words within the sounds. However, the positive dimension of AES was related to the ability to detect words, but not identify the spoken content of the words, partially supporting the idea that HSPs are more aware of subtleties in the environment. However, the lack of association with identification could be due to the degradation of stimuli creating difficulty with accurate speech identification (Nees & Phillips, 2015; Williams & Blagrove, 2022).

Therefore, it seems evident that SPS is an ability construct, in that it is associated with a perceptual advantage of being more aware of the environment, including of sensory and emotional stimuli (Gerstenberg, 2012; Jagiellowicz et al., 2011; Tabak et al., 2022; Williams et al., 2021; Williams & Blagrove, 2022). However, the separability of SPS from the BF was not tested in the latter two studies. It is also unclear whether the perceptual advantage of SPS refers to the detection or the identification of stimuli (Williams & Blagrove, 2022). Koivisto, Grassini, Salminen-Vaparanta, and Revonsuo (2017) have particularly demonstrated how aware detection is possible without aware identification, using event-related potentials (ERPs), commonly used to test perception and attention (Woodman, 2010). This detection and identification distinction is supported by ERP time-course studies (Jimenez, Grassini, Montoro, Luna, and Koivisto, 2018; Koivisto & Revonsuo, 2003).

1.3.Aims and Hypotheses

The aim of the current study was to test the associations between SPS, the BF personality traits, and perceptual ability for the detection and identification of words in degraded images. A task was created that presents participants with a series of images containing words that are visually degraded at three levels of difficulty/degradation. Participants were asked after each image presentation whether they saw a word (to measure detection), and, if they did, to make a guess as to what the word was (to measure identification). Perceptual confidence was also measured.

It was hypothesised that SPS would be related to perceptual ability. No predictions were made regarding differences in the associations with detection and identification. This is because the link between SPS, detection, and identification is not yet clear, as well as which aspects of sensitivity result in or are linked to such advantage, although the positive dimension of AES has been implicated due to it being characterised as increased automatic attentional ability (Williams & Blagrove, 2022; Evans & Rothbart, 2008; Liss et al., 2008; Sobocko & Zelenski, 2015). Additionally, those high in SPS may have lower thresholds at which accurate perception can occur, and these thresholds may differ for detecting versus identifying stimuli (Williams & Blagrove, 2022).

For the current investigation, the PSR and NSR factor model was used, instead of the bifactor/three-factor model, as these two facets may map better onto the positive and negative aspects of high SPS (Tabak et al., 2022). PSR is the same as AES but with the removal of one item (item 5), which seems to be more suited to describing the negative experiences of a HSP (withdrawing during busy days to reduce overstimulation); its removal is also supported by the factor analyses of Tabak et al. (2022). Evans and Rothbart (2008) were the first to find a two-component solution of the HSPS, based on their construct theory of environmental sensitivity, these factors referring to their measures of "Orienting Sensitivity" and "Negative Affect" on the Adult Temperament Questionnaire (Evans & Rothbart, 2007). Orienting Sensitivity refers to perceptive, associative, and affective sensitivity (e.g., awareness of low-intensity stimuli, cognition, and affective awareness), whereas Negative Affect corresponds to sensory discomfort, affective control, negative emotionality, and low sociability. This study especially found the one factor model (Aron & Aron, 1997) to be unsatisfactory, and the three-factor (Smolewska et al., 2006) and two-factor solutions were found to be better, although the conceptual decision to use the two-factor solution was expressed by the authors. Tabak et al. (2022) concur that NSR and PSR are "almost identical to those identified as "Negative Affect" and "Orienting Sensitivity"" (p. 9). For the current study confirmatory factor analyses were conducted regarding the decision to use the two-factor solution to the HSPS, these findings are reported in the Results. Total HSPS score was also calculated as a measure of general environmental sensitivity.

As described above, there has been recent debate that SPS (as measured by the HSPS) is simply a positive redefinition of negatively viewed BF personality traits (Hellwig & Roth, 2021). Associations were thus expected to emerge between SPS and the BF personality traits, particularly with neuroticism, introversion/extraversion, and openness to experience. The study attempted to test this distinction of SPS from these other traits by assessing the relationships of the BF and HSPS with perceptual accuracy.

2. Method

2.1. Participants

Participants were recruited from three sources: Individuals (n = 37) could click a link on social media to take part and choose to be entered into a £20 voucher prize draw; tuniversity participant pool participants (n = 40) could obtain two course credits for taking part; Prolific participants (n = 145) were given monetary payments for participation. Prolific participants were limited, using Prolific's screening settings, to being from the United Kingdom, native English-speaking, and a Prolific approval rate of 90-100%. This sample was also balanced for gender. All participants (regardless of recruitment method) were screened for age (18-50 years) and device usage (desktops only). Prolific participants were screened for these using the built-in Prolific settings.

A total of N = 232 participants were recruited. However, time taken to complete the study was analysed and six participants were flagged as outliers. A further four participants were excluded due to age, slow internet connection, repetitive responses, and having multiple outliers. Thus, the final sample size was N = 222. There were 88 men and 134 women, with a mean age of 29.99 years. 90.9% were White, 3.7% were Black, 2.7% were Asian, and 1.8% were of Mixed Ethnicity. 97.3% of the sample stated that English was their first language, and 94.6% had normal-to-corrected eyesight. Education level is displayed in the Supplementary Materials (Appendix A). This study received ethical approval from Swansea University's School of Psychology Research Ethics Committee and full informed consent was provided by participants.

2.1.1. Sample Size and Power Calculation.

A power calculation conducted using G*Power software (Faul, Erdfelder, Buchner, & Lang, 2007) revealed a sample size of N = 159 would be necessary to achieve an effect size of $f^2 = 0.10$ ($r^2 = 0.09$; from Williams & Blagrove, 2022) with 80% power for a hierarchical regression model with a maximum of 8 predictors. However, this study was not restricted on time or resources, and thus once this target was reached, data collection continued. A sample size of N = 222 was achieved after exclusions, which is comparable to previous research on SPS, personality, and ability measures (e.g., Hellwig & Roth, 2021). A sensitivity analysis (G*Power) revealed that a sample of N = 222 was sensitive enough to detect an effect size of $f^2 = 0.070$ ($r = 0.255$, $r^2 = 0.065$) at 80% power, and an effect size of $f^2 = 0.106$ ($r^2 = 0.096$, $r = 0.310$) at 95% power.

2.2. Stimuli

2.2.1. Word Selection

Words were selected from the English Word Database of EMOtional TErms (EMOTE; Grühn, 2016), a database of 1287 nouns and 985 adjectives. Nouns with 4-5 letters, and 1-2 syllables were included in the process. Words were chosen where imagery, concreteness, meaningfulness, and familiarity had a mean score of 4.00 or more (Mean (M) Imagery = 5.61; M Concreteness = 5.00; M Meaningfulness = 6.31; M Familiarity = 4.24). 186 nouns met these criteria, although one was excluded due to its inappropriateness. Words were then identified according to their valence, and, based on tertiary cut-off points, 45 words were selected. Those with mean valence scores between 1.47 and 3.01 were considered negative (top 15 words), between 3.02 and 4.56 were neutral (middle 15 words), and between 4.56 and 6.08 were positive (top 15 words).

2.2.2. Image Creation

The noisy stimuli were created on PyCharm CE (JetBrains, 2020; Version 3.3), using Python 3.9. Firstly, the program randomly selected which position on a plain white image (500 x 500 pixels) to place each word, with the options being top-right, top-middle, top-left, bottom-right, bottom-middle, bottom-left, centre-right, centre-middle, and centre-left. The lower-case words appeared in black, and the font "Hershey Simplex" was used. The basic size of the words (standard size that is generated) was multiplied by 2.5.

The positions were determined by the axes of the image (i.e., the x and y axes). The words appeared 40 pixels (margin of 8% of the image size) from the edge of the image in each direction (top/bottom; left/right), if they were placed to the top-left, top-right, bottom-left, and bottom-right of the image. If in the centre-middle of the screen, the word was placed halfway from the top and bottom (height; y axis), and the middle of the word was halfway from the left and right (width; x axis). If to the centre-right or centre-left, the word was placed 40 pixels from the (left or right) edge of the image (x axis), and in the middle of the image along the y axis (half the height). If the word was top-middle or bottom-middle, the word appeared 40 pixels from the top or bottom of the screen (depending on position) and half-way between the left and right of the image (half of the width).

Corrections for word length and width were made to ensure words appeared the same regardless of which position they were in, i.e., words began and ended in the correct position. The words placed at the "Top" of the image were corrected for the height of the word, to ensure the top of the word appeared 40 pixels from the top of the image. Words that were placed to the "Left" of the image *began* on the x coordinate. If the word was in the "Centre" of the image, it was corrected for the width of the word, that is, it was shifted to the left according to half of the word width. The result was that the centre of the word was placed on the x and y coordinate (the middle of the image). For those placed on the "Right", the word was shifted to the left by the entire width of the word, so that the word *ended* on the x coordinate.

The program randomly assigned each image to one of three levels of noise (degradation levels) and degraded the image using additive Gaussian noise based on a normal distribution where the mean was equal to 0, and the standard deviation (σ) increased in increments of 250 from Level 1 ($\sigma = 750$), to Level 2 ($\sigma = 1000$), to Level 3 ($\sigma = 1250$). The Gaussian noise was generated, resized to the image dimensions (500 x 500), and then added to image. Additive Gaussian noise (M = 0, σ = 750) was also applied to 15 blank white images (with no word), to create random white noise as a control condition. The noise levels are displayed in Figure 1. There were 13 words degraded at Level 1, 16 at Level 2, 16 at Level 3, and 15 random noise images, resulting in a total of 60 stimuli.

Figure 1. Examples of each degradation level. Figure 1A shows the word "Abuse" degraded at the lowest level (Level 1), located at the bottom-middle of the screen. Figure 1B shows the word "Flood", degraded at Level 2, located at the top-left. Figure 1C contains the word "Smile", degraded at the highest level (Level 3), bottom-left of the screen. Figure 1D is random white noise.

2.2.3. Questionnaires

The Highly Sensitive Person Scale (Aron & Aron, 1997) (HSPS) was used to measure SPS (Cronbach's alpha in the current study was .92). Participants responded to 27 questions with reference to a 7-point Likert scale (1 = Not at all; 7 = Extremely). Mean HSPS score was calculated, with a higher score indicating higher SPS. Mean PSR (6 items) and NSR (19 items) scores were calculated (Tabak et al., 2022), the Cronbach's alpha values found in this study were .75 and .92 respectively.

The 44-item Big Five Inventory (BFI; John, Donahue & Kentle, 1991; John & Srivastava, 1999) was used (Cronbach's alpha = .77). This questionnaire gives participants a series of characteristics to which they respond with how much they agree that the characteristic applies to them, on a 5-point Likert scale of 1 (Disagree Strongly) to 5 (Agree Strongly). Participants were measured across five personality traits, and a mean score was calculated for the following: extraversion (8 items), agreeableness (9 items), conscientiousness (9 items), neuroticism (8 items), and openness to experience (10 items). The Cronbach's alpha values of the subscales were .88, .78, .82, .75, and .79 respectively. John and Srivastava (1999) state that this scale is short, easy to understand, and is efficient in measuring the "core attributes" of each personality trait.

2.3. Procedure

Participants were recruited to take part in an online study titled "*Word Detection Task*", powered by Gorilla Experiment Builder (www.gorilla.sc; Anwyl-Irvine, Massonnie, Flitton, Kirkham, & Evershed, 2019). They read an information sheet and a series of consent statements before providing informed consent by ticking a box on the screen. The participants were naïve to the personality aspects of the study until the questionnaires were presented. Participants were presented with a set of instructions regarding their computer screen and comfort as the task was conducted remotely due to the COVID-19 pandemic, and the researcher had no control over participants' environments. For instance, they were told to sit comfortably, not to sit too close to their screen, approximately 50cm distance was appropriate, and to minimise all distractions. Once they were ready to move on, they clicked a button on the screen. They then read the study instructions. Once ready, they then clicked a button and began the first trial. After a 100 millisecond (ms) onset, a fixation cross was displayed in the centre of the screen for 500ms, then after another 100ms onset, the stimulus was presented on-screen for 1500 ms. After this, the detection question was displayed, "*Did you see a word in the image?*", with the options "*Yes*", or "*No*" presented on the screen. Participants responded by clicking either the "*Yes*" or "*No*" box using their mouse. If they responded "*Yes*", the identification question was displayed, which asked, "*What do you think the word was? Please type in the box below the word you saw in the image, try to make your best guess*." Once they had made their guess, a further response screen asked "*How confident are you in your response? Please rate your confidence by using the slider below. 1 = Not at all confident that I saw the word I stated. 10 = Extremely confident that I saw the word I stated.*". Upon rating their confidence, they moved to the next trial. If participants reported that they did not see a word, they were immediately moved onto the next trial. Each image was displayed in a different random order for each participant, and they were given unlimited time to respond at each response screen (detection, identification and confidence).

The percentage of words detected (*is there a word?*) and percentage of words accurately identified (*what the word says*) were calculated per noise level as well as overall (totalled across the three degradation levels), as a measure of participants' tendency to detect and identify words within white noise. Mean confidence per level was also calculated, as well as overall (totalled across the three levels), as well as mean confidence where participants correctly identified the word and when they did not. Participants completed a demographic questionnaire after the task, where they provided their age, gender, ethnicity, education level, and whether they had normal-to-corrected vision. They also completed the BFI, and the HSPS. Two attention checks were added to the questionnaires, one in the BFI and one in the HSPS to test participants' attention during the study. All participants passed these attention checks.

2.4. Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics for Macintosh, Version 28.0 (IBM Corp, Armonk, N.Y, USA). To test the differences between the levels of degradation, repeated-measures analysis of variance (ANOVA) with pairwise comparisons were conducted, with the levels of degradation as the independent variable, and the dependent variables of the percentage of words detected, the percentage of words identified, and mean confidence score. Bivariate correlations tested for associations between the personality traits (HSPS score, NSR, PSR, openness, extraversion, agreeableness, conscientiousness, and neuroticism), as well as between these traits and the perceptual variables (the percentage of words detected, percentage of words identified, overall mean confidence scores, and mean confidence scores separately for when answers were correct and when incorrect). Multiple linear regressions were conducted to further examine the variance in HSPS score that can be accounted for by the BF personality traits. Due to the assumption that SPS is simply neuroticism, openness, and introversion re-defined, a series of hierarchical regressions were conducted to test these traits as unique predictors of perception, where the three BF traits were entered first and the HSPS subscales second.

Signal Detection Theory was used to test the associations between the personality measures, true perceptual sensitivity, and the tendency to respond with bias. The proportion of words detected at the highest level of degradation (Level 3) were considered “Hits”, whereas the proportion of words detected within the white noise stimuli were considered “False Alarms”. Scores of zero and one were replaced with 0.03 and 0.98 respectively for the proportion of words detected at Level 3, and scores of zero were replaced with 0.03 for the white noise condition. Zeros were replaced according to the formula *0.5 / n* and ones were replaced using the formula *(n - 0.5) / n*, where *n* = the number of trials (16 Level 3, 15 white noise). d’ (perceptual sensitivity) and β (response bias) were calculated to measure the ability of participants to distinguish true signals from noise (d’) as well as their tendency to respond with a bias towards yes or no (β). Larger d’ values correspond to a greater sensitivity to differentiate signals from noise. Larger β (greater than 1) demonstrate a bias towards responding that no words are present (“No”), smaller β values (less than 1) show a bias towards responding words are present (“Yes”) (Stanislaw & Todorov, 1999).

3. Results

3.1. Personality

3.1.1. Descriptive statistics

The descriptive statistics for each personality trait are displayed in Table 1. The mean HSPS score (M = 4.28) is comparable to that found in Study 6 of Aron and Aron (1997) (M = 4.38). Density distributions of the personality measures are displayed in Appendix B.

Table 1. The descriptive statistics for the personality measures, including mean (standard deviation), minimums and maximums.

3.1.2. Confirmatory Factor Analysis of the HSPS

Confirmatory factor analysis (CFA) was conducted to test the appropriateness of the two-factor solution, for NSR and PSR subscales (Tabak et al., 2022), in comparison with the bifactor/three-subscale solution (overall HSPS score, with three subscales of EOE, LST, and AES), first reported by Smolewska et al. (2006). CFA revealed mediocre fit for the bifactor model (higher-order SPS factor, with the three subscales), $X^2(272) = 559.28$, $p < .001$, CFI = 0.859, TLI = 0.844, RMSEA = 0.069 [0.061, 0.077]. The two-factor solution (NSR and PSR; Tabak et al., 2022) also had a mediocre fit, $X^2(298) = 689.75$, $p < .001$, CFI = 0.835, TLI = 0.821, RMSEA = 0.077 [0.069, 0.084]. The two models are thus comparable. These findings accord with the results and conclusions of Evans and Rothbart (2008), who made the conceptual decision to use the two-component solution to the HSPS. We follow that conceptual decision to use the two subscales of NSR and PSR.

3.1.3. Correlations between psychometric measures

Pearson's correlations between the personality measures are displayed in Table 2. Interesting associations to note include the negative correlation between NSR and extraversion, as well as the strong positive correlation with neuroticism. PSR had a strong positive correlation with openness to experience.

A multiple linear regression to predict HSPS score by the BF traits revealed a significant equation, $F(5, 216) = 26.93$, $p < .001$, with an R^2 of 0.384; the BF personality traits accounted for 38.4% of the variance in HSPS score. Extraversion ($p = .04$), neuroticism and openness (*ps* < .001) were significant predictors of HSPS score. The regressions testing the predictions of the BF on the subscales of the HSPS are displayed in the Supplementary Materials (Appendix C).

Table 2. Pearson's bivariate correlations (coefficient, p-value) between the personality measures of HSPS, PSR, NSR, and the BF personality traits. All dfs = 220.

3.2. Differences between levels of degradation

The means of the percentage of words detected, the percentage of words identified, and confidence at all three levels as well as overall, are displayed in Figure 2. Three repeated measures ANOVAs were conducted to test the differences between the percentage of words detected, identified, and confidence scores at each level of degradation; these are displayed in Table 3. The results remained unchanged with the inclusion of white noise, however, as scores were very low (M percentage detected = 0.60, SD = 2.38; M confidence = 0.17, SD = 0.10), the ANOVAs with white noise are not reported. Pairwise comparisons revealed there were significant differences between each level for all perceptual variables ($p < .001$) (Figure 2), indicating that Level 3 was the most difficult for detection and identification, and that participants were least confident at this level.

Table 3. The findings of the repeated measures ANOVAs conducted to test the differences between the levels of degradation on each perceptual variable. Greenhouse-Geisser was used due to the violation of Sphericity.

Paired-samples t-tests revealed significant differences between the percentage of words detected, and between the percentage of words correctly identified, at each level of degradation, as well as overall (all ps < .001) (Figure 2).

Figure 2. The percentage of words detected and correctly identified at all three levels of degradation, as well as overall (left) and the mean confidence scores across the three levels of degradation and overall, for the words that participants correctly identified, incorrectly identified, and total (overall) confidence (right).

Note: There was a significant difference between confidence ratings given when the participants' identification responses were correct and when they were incorrect, $t(221) = 44.44$, $p < .001$.

3.3. Personality and Perception

To test the associations between perception and personality, Spearman's rho correlations were conducted (due to non-normality). All correlation coefficients are displayed in Table 4, and confidence intervals are displayed in the Supplementary Materials (Appendix D). It is important to highlight that, although significant, all correlation coefficients were small ($r_s < .22$). Correlations between the personality variables and detection and confidence in the white noise condition were negligible (detection and confidence r_s range = -.07 to .03, $p > .05$) and thus reported in Appendix E.

Table 4. Spearman's rho correlations and significance values between the personality measures and the perceptual measures. The perceptual measures are the percentage of words detected (detection), the percentage of words correctly identified (identification), and mean confidence scores at all three levels of degradation as well as overall and for correctly identified words and incorrectly identified words separately. All dfs = 220.

* $p < .05$

** $p < .01$

*** $p < .001$

A hierarchical regression was conducted with the three BF personality traits of neuroticism, openness to experience, and extraversion entered in Model 1, and the HSPS subscales of NSR and PSR in Model 2 as predictors of overall detection. Model 1 accounted for 3.7% of the variance in detection scores, and this model was significant, $F(3, 218) = 2.77$, $p = .04$. Model 2 was also significant, $F(5, 216) = 3.35$, $p = .006$, and explained 7.2% of the variance, a significant R^2 change of .035. Standardised coefficients are displayed in Table 5. Extraversion and PSR were significant predictors, with extraversion negatively predicting detection. The regression remained unchanged with the addition of gender.

The same analysis was conducted for overall identification. Firstly, the three BF personality traits were entered into Model 1, and then NSR and PSR were added in Model 2. Model 1 accounted for 5.5% of the variance in detection scores, and this model was significant, $F(3, 218) = 4.26$, $p = .006$. Model 2 was also significant, $F(5, 216) = 4.16$, $p = .001$, and explained 8.8% of the variance, a significant R^2 change of .032. Standardised coefficients are displayed in Table 5. Extraversion negatively predicted and PSR positively predicted identification scores, the regression remained unchanged with the addition of gender.

Next, Signal Detection Theory d' (perceptual sensitivity) and β (response bias) were calculated. The correlations between these measures and personality are displayed in the Supplementary Materials (Appendix F). The only significant (small) associations were found between PSR and d' ($r(220) = .232$, $p < .001$), openness to experience and d' ($r(220) = .186$, $p < .001$), and openness and β ($r_s(220) = -.163$, $p < .05$). A hierarchical regression was conducted, with the three BF traits entered as predictors of perceptual sensitivity (d') in Model 1 and the PSR and NSR subscales of the HSPS in Model 2. The findings are displayed in Table 5. From Model 1 to Model 2, there was a significant R^2 change of .036, suggesting that the subscales of the HSPS predicted perceptual sensitivity beyond the BF, PSR and extraversion once again predicted perceptual sensitivity. The regression remained unchanged with the addition of gender as a predictor. The hierarchical regression with response bias was non-significant ($p > .05$) and thus not reported.

Table 5. Hierarchical regression analysis of predictors of the overall (total) percentage of total words detection and overall (total) percentage of words correctly identified, and perceptual sensitivity (d'). Standardised coefficients are reported.

*$p < .05$

**$p < .01$

Six regressions were conducted with PSR as a predictor of the percentage of words detected and words correctly identified at each level of degradation. Full statistics are displayed in Table 6. The models with Level 2 and Level 3 detection and identification were significant.

Table 6. Model statistics for linear regressions with PSR as a predictor of the percentage of words detected and percentage of words accurately identified at each level of degradation.

	Detection			Identification		
	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
Model						
F	0.30	7.21	10.58	2.15	9.24	5.91
p	.87	.008*	.001*	.14	.003*	.02*
R^2	.000	.032	.046	.010	.040	.026

* Significance

4. Discussion

This study firstly tested the associations between the BF personality traits and HSPS. The findings were in line with the previous literature, specifically revealing moderate-to-strong associations between HSPS and neuroticism, openness to experience, and extraversion (Smolewska et al., 2006; Grimen & Diseth, 2016; Yano et al., 2019; Bröhl et al., 2020; Tabak et al., 2022; Hellwig & Roth, 2021), traits that have been claimed to capture the entirety of SPS as measured by the HSPS (Hellwig & Roth, 2021). In particular, PSR was related to openness, and NSR with extraversion and neuroticism. The correlations found between HSPS and the BF personality traits, using bivariate correlations, were smaller than those found using latent variable correlations in Hellwig and Roth (2021), but are comparable to previous studies (e.g., Smolewska et al., 2006; Lionetti et al., 2019).

Secondly, the study sought to assess whether behavioural measures are differentially associated with the HSPS and BF traits, by testing the correlations between BF and HSPS with the detection and identification of degraded stimuli at differing levels of difficulty using a newly devised and validated perceptual method. Importantly, we found that the PSR dimension of the HSPS was related to perceptual ability, that is detection and identification scores, beyond neuroticism, introversion, and openness to experience, showing that SPS cannot be reduced to BF variables, contrary to Hellwig and Roth (2021). The question thus arises of how the HSPS is associated with such perceptual advantages. Williams and Blagrove (2022) found that individuals high in AES were able to detect the presence of voices that had been degraded within white noise, although there was no evidence to suggest a heightened ability to identify the spoken content of these voices. This raises the question of whether high SPS indicates low perceptual thresholds, such that accurate perception, in this case identification, can occur. In the current study, SPS (specifically PSR) predicted the percentage of words detected and identified at Level 2 and Level 3. However, the predictive power of PSR seemed stronger for Level 2 identification than Level 2 detection, as well as stronger for Level 3 detection than Level 3 identification. This implies that HSP have an advantage at detecting stimuli at higher levels of difficulty, but the threshold for identification may be higher and require lower levels of degradation for accurate identification to occur. Thus, the predictive power of PSR for identification peaked at Level 2. Nevertheless, it seems that high HSPS individuals possess a perceptual advantage for both detecting and identifying stimuli, and their thresholds at which this can occur may be lower than non-sensitives, particularly for detection, which supports the bottom-up account of high SPS (Williams et al., 2021).

Importantly, the finding that there is a perceptual advantage of being a Highly Sensitive Person may balance the disadvantage of being easily overwhelmed and stimulated. This also indicates an evolutionary advantage and strategy for high, medium, and low SPS individuals (as well as in other mammals), in that the factors driving environmental sensitivity may be exaggerated more in highly sensitives (Lionetti et al., 2018). For instance, Lionetti et al. (2018) suggest that highly sensitives ("orchids") have higher levels of emotional reactivity (positive and negative), but present as more introverted, whereas low sensitives ("dandelions") are more extraverted and score lower on emotional reactivity. The highly sensitives ("orchids") constitute approximately 15-30% of the population (Aron & Aron, 1997; Lionetti et al., 2018), with an interesting personality profile of an individual who is highly reactive to internal and external stimuli, processes sensory information more deeply, and is inherently flexible and appreciative of aesthetics, often with high neuroticism, openness to experience, and introversion. There thus remains the perspective that SPS is predominantly a combination of these BF traits. Therefore, it is important to consider here the "jangle fallacy", which refers to using different words to refer to what is one concept (Pekrun, 2023), in this case, the perspective that SPS is a combination of high neuroticism, openness to experience, and low extraversion. While recognising this, the findings here that the perceptual advantage of SPS does not hold for BF personality traits suggests, following Gonzalez, MacKinnon, and Muniz (2021), that the construct of SPS is not solely an inadvertent result of the "jangle fallacy".

Thus, although SPS is not the same as the combination of these traits, given its unique perceptual component, we consider what causality may be present for this association between SPS and BF. One possibility is that the BF personality profile develops in some individuals *as a result* of high SPS. For instance, if an individual is susceptible to experiencing negative stimuli and environments more negatively, and positive stimuli and environments more positively (differential susceptibility; Belsky, 1997; Belsky & Pluess, 2009), they may be more likely to develop personality traits that correspond to these experiences. Thus, overstimulation from social experiences may result in introverted tendencies and/or behaviours, as well as increased emotionality. However, the development of traits is difficult to test, and would need to involve measures of environmental sensitivity and personality development across the lifespan (at least into adulthood).

4.1. Limitations

One limitation of the current study is online data collection. As a result of the COVID-19 pandemic, traditional methods of collecting behavioural data were postponed due to the restrictions imposed by government bodies, meaning online methods had to be adopted as an alternative. The consequence of this was the lack of control over the participants' environments. For instance, the computer screen was especially important in this study due to the visual nature of the task, and any difference in computer brand, model, size, and screen angle may have impacted upon viewing, thus influencing the perception of the noisy images. Also, although participants were instructed to sit approximately 50cm away from their screen, they could have ignored this and sat very close to optimise viewing, or simply zoomed in to "cheat". Furthermore, distractions could have been present during the task, posing implications on participants' attention and consequently, their responses. Attempts were made to minimise these by including detailed instructions of computer screen set-up, comfort, and the minimisation of distractions. Also, time taken to complete the task was analysed and all outliers were excluded, and attention checks were added to test if all paid attention (not just clicking buttons) as well as to eliminate the possibility of "bots" (Eerola, Armitage, Lavan, & Knight, 2021). Nevertheless, variability in performance could have resulted from the above factors.

A second limitation is that the majority (n = 145) of participants were recruited using the online data collection platform Prolific. Crowdsourcing platforms have increased in popularity in recent years due to their convenience and fast data collection abilities while maintaining high quality data, specifically for personality research (Buhrmester, Talaifar, & Gosling, 2018; Eerola et al., 2021). However, the quality and how this compares to other platforms and traditional lab settings is still disputed (Anwyl-Irvine, Dalmaijer, Hodges, & Evershed, 2020; Elliot, Bell, Gorin, Robinson, & Marsh, 2020; Litman, Moss, Rosenzweig, & Robinson, 2021; Peer, Rothschild, Gordon, Evernden, & Ekaterina, 2021; Spinde, Krieger, Plank, & Gipp, 2021) although Prolific has been indicated as a reputable data source (e.g., Elliot et al., 2020; Stanton, Carpenter, Nance, Sturgeon, Villalongo, 2022).

The majority of participants were from the United Kingdom and of White ethnic backgrounds. This is a limitation because SPS varies depending on country, with, for example, individuals from countries such as Belgium scoring higher on the positive subscale of the HSPS than British participants (Greven et al., 2019). Also, although attempts were made to balance the sample for gender, there was a higher proportion of women to men. With differences between men and women in the BF traits, as well as cross-culturally (Costa, Terracciano, & McCrae, 2001; Schmitt, Realo, Voracek, & Allik, 2009), caution is to be taken when generalising these results to different cultures, and, although gender was checked as a covariate in analyses here, a more equal sample size for males and females should be aimed for when testing for associations with personality.

One view emerging in the literature is that the HSPS is not sufficient in measuring environmental sensitivity (Greven et al., 2019; Hellwig & Roth, 2023), shown in this study by the mediocre fit indices, which raises the need for either improvements of the scale or perhaps a new construct measure. For example, De Gucht, Woestenberg, and Wilderjans (2022) recently created and validated a new measure of environmental sensitivity "that maps not only negative but also a broad range of positive aspects of Sensory Processing Sensitivity" (p. 2), referred to as the Sensory Processing Sensitivity Questionnaire (SPSQ; The scale has already been shortened to a 26-item version (De Gucht & Woestenburg, 2024), and has been translated into Spanish (Salinas-Quintana et al., 2024)). The SPSQ presents six different dimensions arranged within a positive and negative domain, with each dimension measuring different aspects of high sensitivity. Their findings, and new construct measure, suggest multiple factors that constitute the trait of SPS, with a clear distinction between a positive and negative aspect. The authors specifically emphasise the importance of considering not only these two domains, but the six individual dimensions when measuring SPS. Thus, future research could include the SPSQ to test it as a measure of environmental sensitivity, how it compares to the HSPS, and its unique associations with, for example, perceptual measures.

Finally, no measure of orienting sensitivity (temperament) was included in the current study. As SPS is considered to be a temperamental sensitivity with two underlying constructs (Evans & Rothbart, 2008) it would be interesting to see whether there are overlaps between the HSPS and measures of temperament, such as the Adult Temperament Questionnaire (ATQ; Evans & Rothbart, 2007). A further suggestion is to use an extensive measurement scale, such as the SPSQ (DeGucht et al., 2022), which uses items from many separate questionnaires, including the ATQ and the HSPS, as an encompassing measure of environmental sensitivity.

4.2. Conclusion

This study has shown the enhanced perceptual ability of high PSR scorers, evidenced as increased detection and identification of visually degraded words, and importantly this dimension of SPS was shown to predict perception beyond the variance accounted for by BF traits. This contradicts the view that SPS is simply a positive redefinition of neuroticism, low extraversion, and openness to experience, and supports the independent construct account of SPS and of the HSPS measure of SPS. The perceptual advantage for highly sensitives may balance the disadvantages of being easily overwhelmed by stimuli and indicates separate evolutionary advantages and strategies for high and low SPS humans and other mammals.

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Supplementary Materials

Appendix A.

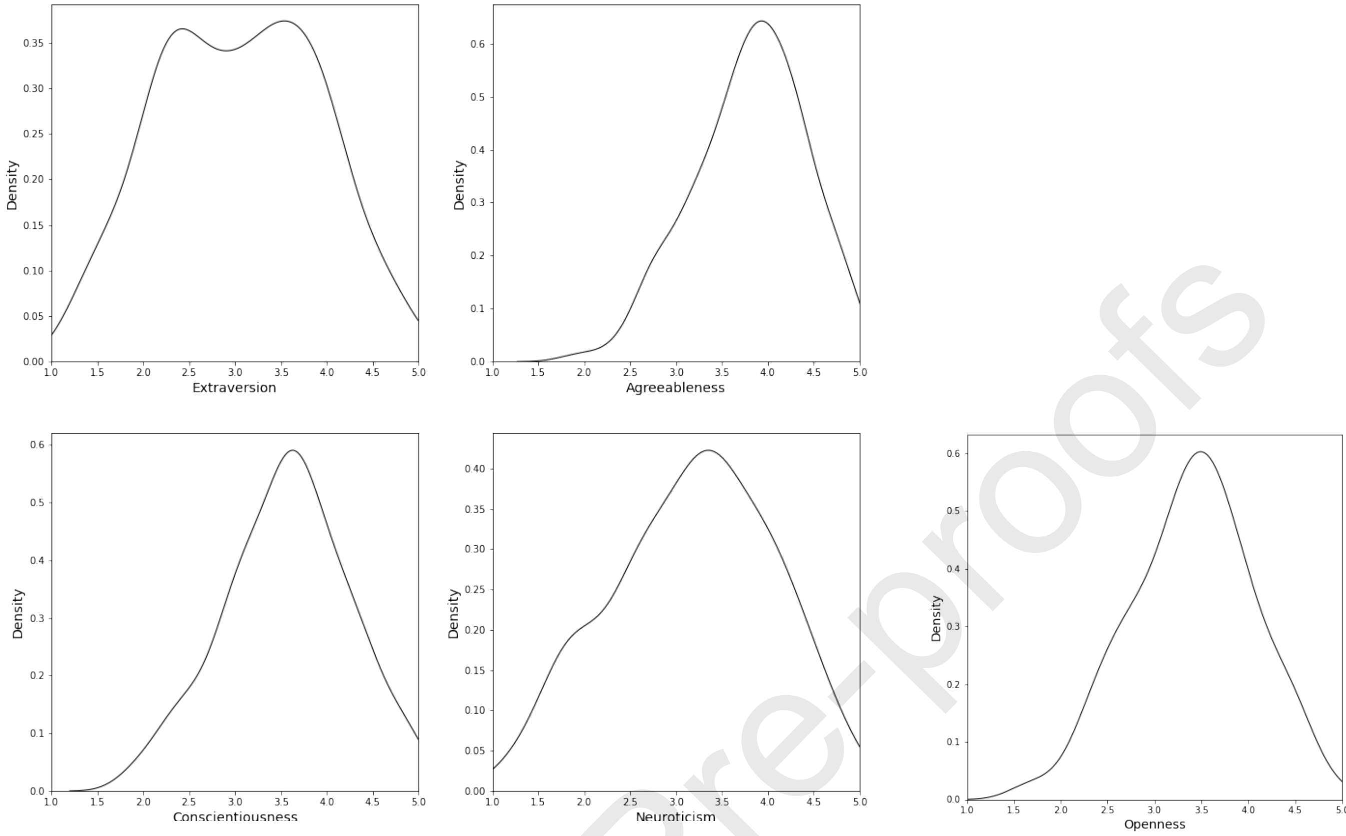
The frequency and percentage of participants that had achieved educational qualifications.

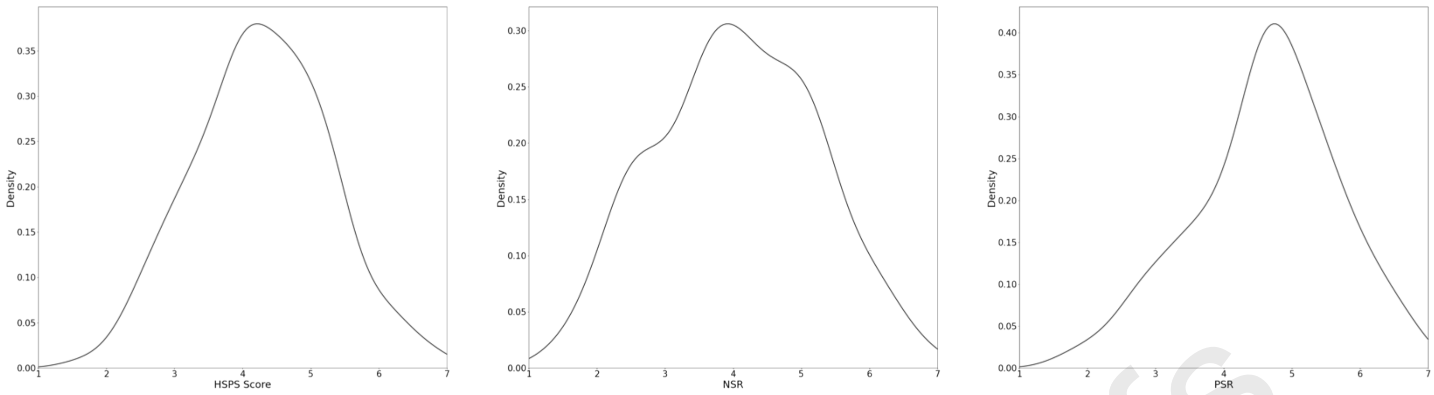
Education Level	Frequency of Responses	Percentage of Sample
Doctoral Degree or Equivalent	5	2.3
Master's Degree or Equivalent	29	13.2
Bachelor's Degree or Equivalent	69	31.4
A-Levels or Equivalent	91	41.4
GCSE's A*-C or Equivalent	20	9.1
Other Qualifications	5	2.3
No Qualifications	1	0.5
No Response	2	0.5

Two participants did not give a response.

Appendix B.

Density distribution graphs of the personality measures.





Appendix C.

***Regressions with HSPS subscales and BF traits*. Standardised Coefficients reported**

Predictors	NSR	PSR
Extraversion	-.164**	.072
Agreeableness	-.003	.053
Conscientiousness	-.016	.191***
Neuroticism	.544***	.201***
Openness	.184***	.595***
F(5, 216), p	28.952, $p < .001$	33.030, $p < .001$
R^2	.395	.420

** $p < .01$

*** $p < .001$

Appendix D.

Spearman's rho confidence intervals (upper, lower) for the correlation coefficients between the personality variables and perceptual variables.

	Detection				Identification				Confidence					
	Level 1	Level 2	Level 3	Overall	Level 1	Level 2	Level 3	Overall	Level 1	Level 2	Level 3	Overall	Correct	Incorrect
HSPS Score	-.146, .125	-.161, .110	-.084, .186	-.108, .163	-.073, .197	-.089, .181	-.141, .130	-.083, .188	-.203, .067	-.214, .056	-.117, .154	-.194, .077	-.293, .003	-.160, .111
NSR	-.160, .111	-.186, .084	-.128, .143	-.152, .119	-.093, .178	-.126, .041	-.178, .093	-.123, .148	-.221, .048	-.242, .026	-.166, .105	-.233, .036	-.278, -.013	-.161, .110
PSR	-.105, .165	-.023, .244	.068, .328	.063, .323	-.054, .215	.041, .304	.015, .280	.057, .318	-.068, .202	.020, .284	.089, .347	.053, .314	-.082, .188	-.131, .140
Extraversion	-.143, .128	-.203, .067	-.169, .102	-.164, .107	-.211, .059	-.225, .044	-.142, .129	-.210, .060	-.150, .121	-.084, .186	-.006, .260	-.054, .215	.003, .269	.126, .380
Conscientiousness	-.094, .177	-.011, .255	-.122, .149	-.098, .173	-.090, .181	-.091, .180	-.064, .205	-.074, .196	-.025, .242	.025, .289	-.050, .219	.011, .276	.025, .299	-.100, .171

Agreeableness	-.006, .260	-.043, .225	.007, .273	.012, .277	-.005, .261	-.074, .196	.034, .298	.006, .272	.017, .282	-.024, .244	.071, .331	.042, .305	-.062, .207	-.113, .158
Neuroticism	-.156, .115	-.112, .159	-.127, .144	-.135, .136	-.138, .133	-.205, .064	-.195, .075	-.193, .077	-.204, .066	-.271, -.005	-.179, .092	-.246, .021	-.237, .031	-.215, .054
Openness	-.116, .155	.013, .278	.081, .340	.088, .346	-.041, .228	.029, .293	-.013, .254	.027, .291	.003, .269	.052, .314	.078, .337	.087, .345	-.022, .245	-.094, .177

Appendix E.

Spearman's rho correlations (coefficient, p-value) between the personality variables with detection and confidence in the White Noise condition (all dfs = 220).

	Detection	Confidence
HSPS Score	-.034, p = .62	-.035, p = .61
NSR	-.022, p = .74	-.024, p = .73
PSR	-.024, p = .72	-.024, p = .72
Extraversion	.009, p = .89	.008, p = .90
Conscientiousness	-.058, p = .39	-.057, p = .40
Agreeableness	.009, p = .89	.007, p = .91
Neuroticism	.018, p = .79	.017, p = .80
Openness	-.010, p = .88	-.012, p = .86

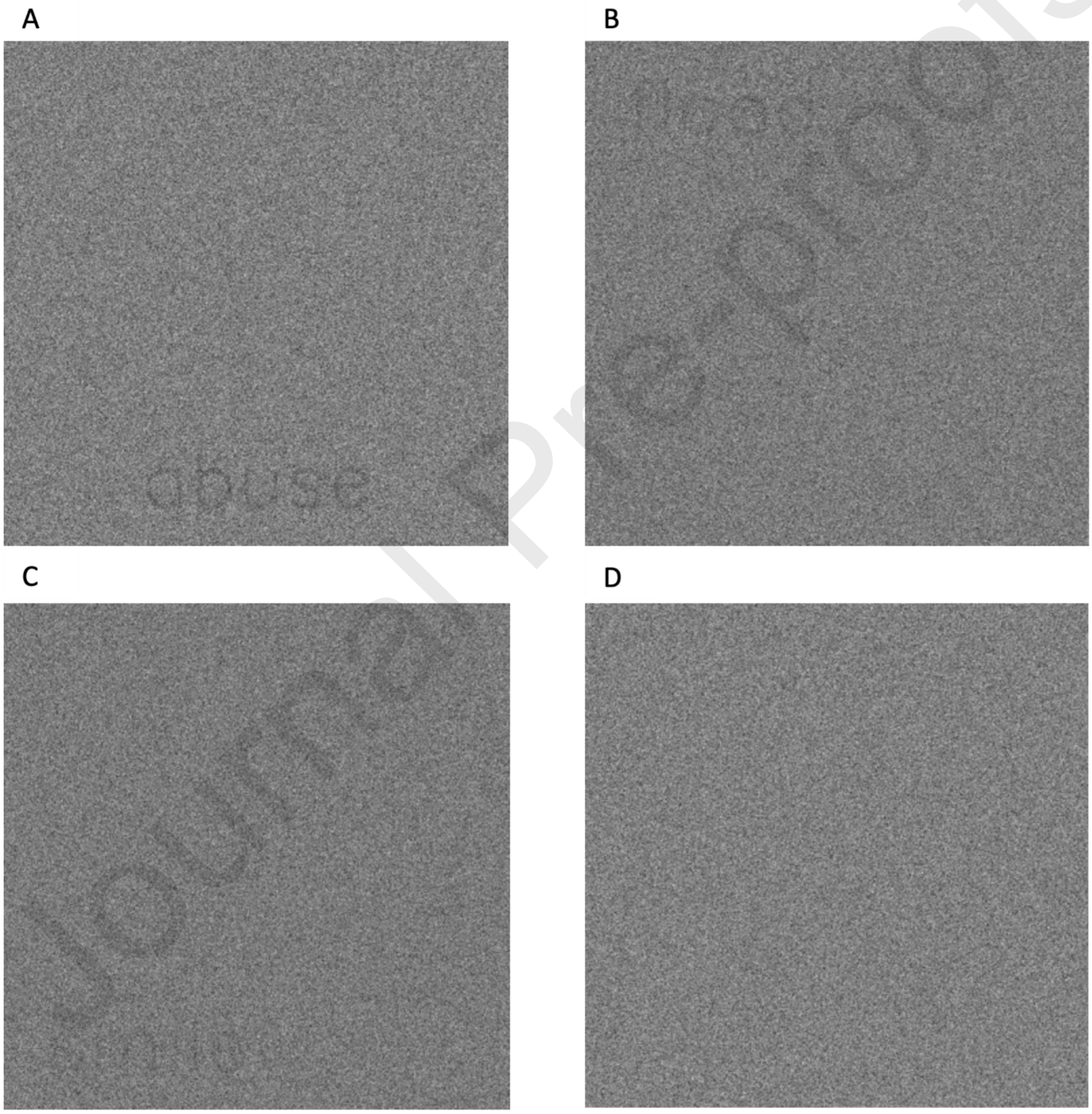
Appendix F.

Detection Measures, including perceptual sensitivity and response bias. **Pearson's correlations were conducted for perceptual sensitivity, and Spearman's Rho (r_s) for response bias, due to non-normality. All dfs = 220.**

	Perceptual Sensitivity (d')	Response Bias (β)
HSPS Score	.092	.035
NSR	.035	.074
PSR	***.232	-.116
Extraversion	-.059	-.074
Conscientiousness	.035	.024
Agreeableness	*.158	-.001
Neuroticism	.009	.036
Openness	***.186	*-.163

* $p < .05$

*** $p < .001$


A
B
C
D
abuse

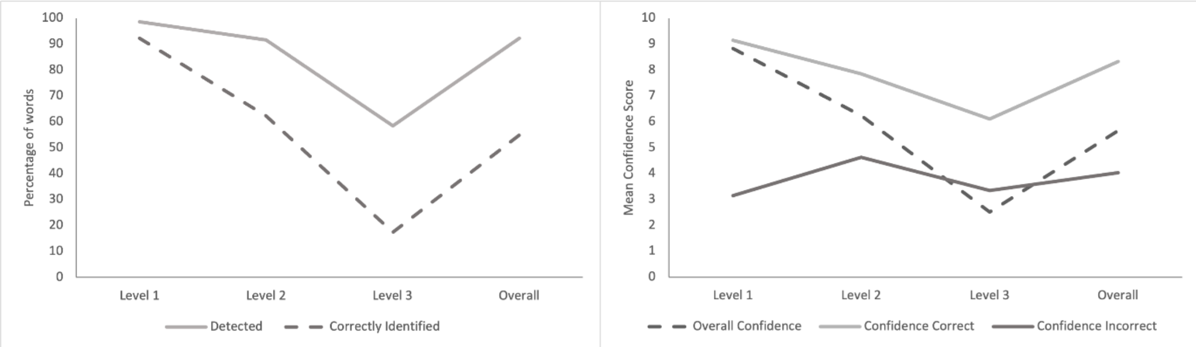


Table 1.

	Mean (SD)	Minimum	Maximum
HSPS Score	4.28 (0.99)	1.59	6.93
NSR	4.06 (1.17)	1.32	7.00
PSR	4.62 (1.06)	1.67	7.00
Extraversion	3.04 (0.87)	1.25	5.00
Conscientiousness	3.57 (0.68)	1.89	5.00
Agreeableness	3.80 (0.61)	1.89	5.00
Neuroticism	3.18 (0.87)	1.13	5.00
Openness	3.41 (0.67)	1.60	5.00

Table 2.

	HSPS Score	NSR	PSR	Extraversion	Conscientiousness	Agreeableness	Neuroticism
NSR	.971, *p* < .001	-	-	-	-	-	-
PSR	.589, *p* < .001	.387, *p* < .001	-	-	-	-	-
Extraversion	-.238, *p* < .001	-.324, *p* < .001	.183, *p* = .006	-	-	-	-
Conscientiousness	-.109, *p* = .105	-.196, *p* = .003	.202, *p* = 002	.202, *p* = .003	-	-	-
Agreeableness	-.086, *p* = .201	-.150, *p* = .026	.155, *p* = .021	.251, *p* < .001	.313, *p* < .001	-	-
Neuroticism	.540, *p* < .001	.590, *p* < .001	.050, *p* = .459	-.362, *p* < .001	-.291, *p* < .001	-.223, *p* < .001	-
Openness	.228, *p* < .001	.094, *p* = .164	.610, *p* < .001	.221, *p* < .001	.065, *p* = .335	.116, *p* = .086	-.096, *p* = .152

Table 3.

	F(df)	*p*	ηp^2
Percentage of words detected	592.01 (1.34, 296.07)	< .001	.73
Percentage of words identified	3103.44 (1.74, 383.47)	< .001	.93
Mean Confidence	3200.86 (1.96, 432.46)	< .001	.94

Table 4.

	Detection				Identification				Confidence					
	Level 1	Level 2	Level 3	Overall	Level 1	Level 2	Level 3	Overall	Level 1	Level 2	Level 3	Overall	Correct	Incorrect
HSPS Score	-.010	-.026	.052	.028	.063	.047	-.006	.053	-.070	-.080	.019	-.060	*-.133	-.025
NSR	-.025	-.052	.007	-.017	.043	.010	-.043	.012	-.088	-.110	-.031	-.100	*-.148	-.026
PSR	.030	.113	**.201	**.196	.082	**.175	*.150	**.191	.068	*.155	***.222	**.187	.054	.005
Extraversion	-.008	-.069	-.034	-.029	-.077	-.093	-.006	-.076	-.014	.052	.130	.082	*.139	***.257
Conscientiousness	.042	.124	.014	.038	.047	.045	.072	.062	.110	*.160	.086	*.146	*.170	.036
Agreeableness	.129	.093	*.143	*.147	.130	.062	*.169	*.142	*.152	.112	**.204	*.177	.074	.023
Neuroticism	-.021	.024	.008	.001	-.003	-.072	-.061	-.059	-.071	*-.140	-.044	-.114	-.105	-.082
Openness	.020	*.149	***.214	***.221	.095	*.164	.123	*.162	*.139	**.186	**.211	***.220	.113	.042

* $p < .05$

** $p < .01$

*** $p < .001$

Table 5.

Predictor Variables	Overall Detection		Overall Identification		Perceptual Sensitivity (d')	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Extraversion	-.095	-.151*	-.181*	-.219**	-.109	-.161*
Neuroticism	.003	.059	-.114	-.111	-.010	.031
Openness	.188**	.060	.189**	.048	.210**	.072
NSR		-.173		-.072		-.148
PSR		.265**		.255**		.273**
R^2	.037	.072	.055	.088	.045	.081
R^2 Change		.035*		.032*		.036*

F	2.77*	3.35**	4.26**	4.16**	3.46*	3.83**

*$p < .05$

**$p < .01$

Table 6.

	Detection			Identification		
	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
Model						
F	0.30	7.21	10.58	2.15	9.24	5.91
p	.87	.008*	.001*	.14	.003*	.02*
R^2	.000	.032	.046	.010	.040	.026

* Significance

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