Sensory Processing Sensitivity: Associations with the Detection of Real Degraded Stimuli, and Reporting of Illusory Stimuli and Paranormal Experiences

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Running Head: Sensory Processing Sensitivity and auditory recognition

Abstract

There are differences in Sensory Processing Sensitivity (SPS) within many species. In humans high SPS refers to greater responsivity to stimuli, slower, deeper processing, aesthetic sensitivity, and low threshold for sensory discomfort. This study tested whether SPS is associated with the accurate recognition of degraded auditory stimuli and susceptibility to auditory pareidolia (hearing illusory words when presented with ambiguous, degraded words). Fifty participants (mean age = 33.02; females *n* = 32, males *n* = 18) responded to degraded words presented in Deutsch's phantom word illusion task. They then completed the Highly Sensitive Person Scale, which assesses SPS, and the Survey of Anomalous Experiences. SPS was significantly associated with the recognition of degraded stimuli, but not with pareidolia. Number of anomalous experiences reported by participants was significantly associated with SPS and pareidolia. This study shows objective validation of the Highly Sensitive Person Scale regarding detection of subtle external stimuli.

Keywords: Sensory Processing Sensitivity; Highly Sensitive Person Scale; Highly Sensitive Person; auditory stimuli recognition; pareidolia; anomalous experience; paranormal experience.

1. Introduction[1]

1.1 Characteristics of Sensory Processing Sensitivity

[1] Abbreviations: AES: aesthetic sensitivity; EOE: ease of excitation; HSP: Highly Sensitive Person; HSPS: Highly Sensitive Person Scale; LST: low sensory threshold; SAE: Survey of Anomalous Experiences; SPS: Sensitive Processing Sensitivity.

Sensory Processing Sensitivity (SPS) is a trait reflecting levels of awareness of, and responsivity to subtle physical, social, and sensory stimuli, depth of cognitive processing of stimuli, emotional reactivity, aesthetic sensitivity, and ease of overstimulation (Aron, Aron, & Jagiellowicz, 2012). The term Highly Sensitive Person (HSP) and the Highly Sensitive Person Scale (HSPS) were devised by Aron and Aron (1997) to identify individuals who experience high SPS. The HSPS consists of 27 items which address, for example, being more sensitive to pain, hunger, and caffeine, thinking deeply, being deeply moved by the arts or music, being easily startled, and not liking violent films. Aron and Aron (1997) characterize HSPs as being cautious in the face of novel stimulation, showing quiet exploration and vigilance, and using a checking mode which looks for mismatches and risk in the environment.

SPS correlates with many health behaviors and outcomes, for example, social anxiety (Hofmann & Bitran, 2007), burnout (Meyerson, Gelkopf, Eli, & Uziel, 2020), and general psychological health complaints (Grimen & Diseth, 2016). High SPS can also create greater vulnerability to poor parenting and other stressors, leading to neuroticism and shyness (Aron, Aron, & Davies, 2005). It has also been linked to the frequent experience of nightmares, mediated by emotional reactivity to adverse environments and moods (Carr, Matthews, Williams, & Blagrove, 2020; Carr & Nielsen, 2017), and nightmare distress (Carr et al., 2021). Conversely, positive implications are that high SPS is related to greater awareness of novel, social stimuli (Acevedo et al., 2014), greater empathy (Aron, 2010), and being more responsive to, and flourishing from emotionally positive stimuli and environments (Jagiellowicz, Aron, & Aron, 2016).

Although the factor analysis of results in Aron and Aron (1997) showed the HSPS to be unidimensional, and Aron (2010, pp.234-237) points out that there are inconsistencies

between findings or claims of dimensions in the HSPS, Smolewska, McCabe, and Woody (2006) report three distinct dimensions of the HSPS. They labelled these ease of excitation (EOE; e.g., 'Do you find it unpleasant to have a lot going on at once?'), aesthetic sensitivity (AES; e.g., 'Are you deeply moved by the arts or music?'), and low sensory threshold (LST; e.g., 'Are you made uncomfortable by loud noises?'). The current investigation thus includes these three dimensions as well as the overall HSPS dimension.

1.2 Behavioral validity of HSPS

With the emphasis in the literature on brain and physiological correlates of SPS, and on its health and behavioral consequences, there has been very little research to examine the behavioral validity of the HSPS. For example, Greven et al. (2019) review the five fMRI studies of SPS, and genetic studies, and behavioral studies of environmental reactivity and awareness of environmental subtleties. Findings include heightened reactivity of brain areas composing the default network, which mediate internal mentation, and networks underpinning attention toward salient and emotional stimuli. Yet, whereas this literature is informative about the neural basis for SPS, and its health and behavioral consequences, and that individual members of many species differ along a continuum of act first versus pause first, Greven et al. (2019) conclude that the field requires the investigation of other objective characteristics of SPS.

In a review and meta-framework of SPS and related sensitivity concepts and models, Pluess (2015) defines environmental sensitivity as comprising 'the ability to register, process, and respond to external factors.' This definition and the distinctions within it raise the question of whether SPS might be characterized by enhanced recognition of stimuli, in addition to intensity of reactions to stimuli. Only two studies have addressed this: Gerstenberg (2012) found SPS to be positively correlated with fewer errors in a visual

detection task, but only for the Low Sensory Threshold dimension of the HSPS, and Jagiellowicz et al. (2011) found HSPS score was not associated with accuracy in a visual change detection task.

Given the lack of clarity in the literature on SPS and visual perceptual accuracy, and so as to extend this work to another modality, the current study aimed to test whether SPS is associated with the accurate recognition of degraded auditory stimuli. However, there are two possible aspects to such stimulus sensitivity. The first is the accurate recognition of real, degraded stimuli; the second is pareidolia, the misperception of random or degraded stimuli such that illusory words are heard. To test these two variables, the current study used the phantom word illusion, an effect created by Deutsch (2003, 2019). This method consists of two-syllable words spoken at approximately four times normal speed over loudspeakers through two different stereo channels. The words are presented alternately, from the two locations, and as a result participants hear illusory words that are not there, as well as, for some participants, hearing the degraded words that are present. The first aim of the current study was to assess the hypothesized relationship of SPS to the recognition of degraded stimuli, and also to assess whether high SPS is associated with the hearing of illusory words.

1.3 SPS and anomalous and paranormal experiences

The second aim of this study was to investigate whether SPS is related to the reporting of paranormal experiences. For this, Jawer's (2006) scale of neurobiological environmental sensitivity has been shown to be associated with reporting anomalous experiences. This measure of sensitivity, characterized by susceptibility to stimuli and emotional sensitivity, displays similarities to the HSPS, and thus it may be that those with high SPS as measured by the HSPS also have such anomalous experiences. Similarly, Irwin,

Schofield, and Baker (2014) demonstrated a significant relationship between score on the HSPS and reporting a larger number of anomalous experiences, and more paranormal attributions of such experiences, the latter two variables measured using the Survey of Anomalous Experiences (SAE; Irwin, Dagnall, & Drinkwater, 2013). Irwin et al.'s (2014) study, however, did not include participants who reported having had no anomalous experiences. The present study extends Irwin et al. (2014) by including the full range of paranormal experience and non-experience. Previous studies have found that the full range of anomalous experience/non-experience correlates with individual differences such as lack of knowledge of statistical principles and susceptibility to confirmation bias (Blagrove, French, & Jones, 2006), susceptibility to false memory (Clancy et al., 2002; Wilson & French, 2006), and perceptual and attentional biases (van Elk, 2015).

1.4 Auditory pareidolia and anomalous and paranormal experiences

The third aim addressed whether auditory pareidolia may also be associated with paranormal experiences, in that unstructured stimuli can result in the perception of patterns in the environment (Chalup & Hong, 2010). Although possibly acting as an aid for our ancestors in the detection of threats, this interpretation, or misinterpretation of ambiguous stimuli may cause individuals to experience what they conclude to be anomalous or paranormal occurrences (Lange & Houran, 1998). For example, Nees and Phillips (2015) found that the mere expectation of the paranormal caused participants to hear ghost voices in random noise, termed Electronic Voice Phenomena. Visual pareidolia has also been found to be common in paranormal believers (Riekki et al., 2013).

1.5 Hypotheses

Four hypotheses were devised: 1) There is an association between SPS and the recognition of degraded stimuli; 2) There is an association between SPS and pareidolia; 3)

There is an association between SPS and reporting of anomalous and paranormal experiences; and 4) There is an association between pareidolia and reporting of anomalous and paranormal experiences. For hypotheses 1 to 3, SPS was measured using the HSPS.

1.5.1 Non-hypothesized relationships with HSPS dimensions

We also aimed to perform exploratory correlations using the three HSPS dimensions reported by Smolewska et al. (2006). We did not hypothesize which, if any, of the three dimensions would show significant correlations with the degraded stimuli recognition, pareidolia, and anomalous and paranormal experience measures.

2. Method

2.1 Participants

Fifty participants were recruited through an opportunity sample, replying to a request on social media, or were members of the public recruited in a retail area. There were 18 males and 32 females, with an age range of 20 to 57 (M = 33.02, SD = 11.05). Participation was voluntary, and all gave written informed consent to take part. The study had ethics approval from the institutional Research Ethics Committee.

2.2 Sample size and Power

The only finding in the literature of a significant relationship between performance on a sensory detection task and the HSPS was for error rate and the LST dimension, in Gerstenberg (2012), where the Pearson correlation r=.42. A minimum sample size of N = 50 for the current study was determined by a power analysis conducted using G*Power software (Faul, Erdfelder, Buchner, & Lang, 2009), at a power of .80, alpha of .025, and r =.42. A threshold alpha of .025 was used in this calculation because of the aim of using two measures of auditory performance, and was thus a correction for multiple correlations.

2.3 Apparatus

The CD *Diana Deutsch: Phantom Words and Other Curiosities* (2003) was copied and imported to the iTunes Library on an Apple MacBook Air (2017). Two Sony SRS-X11 Bluetooth speakers were paired with the MacBook. The speakers were placed approximately 60cm apart, to the left and right of the participant, and each approximately 60cm from the participants' head.

2.4 Measures

2.4.1 Sensory Processing Sensitivity

The Highly Sensitive Person Scale (HSPS: Aron & Aron, 1997) was used in order to measure SPS. On each of the 27 items participants rate themselves on questions about environmental sensitivity and reactions to sensory input. For example, 'Are you easily overwhelmed by strong sensory input?', 'Do you startle easily?', and 'Does being very hungry create a strong reaction in you, disrupting your concentration or mood?' Each question was rated with reference to a 7-point Likert scale, where 1 = Not at All, and 7 = Extremely. Individual item scores were summed to give a total sensitivity score. Dimension scores (EOE; AES; LST) were also calculated, following Smolewska et al. (2006). Cronbach's alpha statistics for the sample (*N*=50) were: HSPS, alpha = .84 (27 items); EOE, alpha = .72 (12 items); AES, alpha = .70 (7 items); LST, alpha = .71 (6 items).

2.4.2 Behavioral stimulus sensitivity and pareidolia

Participants were presented with tracks 2 to 7 of Diana Deutsch: *Phantom Words and Other Curiosities* (2003). The tracks were titled: Boris, Go-Back, Harvey, Igor, No-Where, and Hilda. Each track lasted 2 minutes, and continuously repeated the one or two words of the title from the two speakers alternately, at a rate approximately four times faster than normal speech. Participants listened to the tracks and reported simultaneously out loud any words that they heard during the task. The different words reported for each track were

recorded by hand on a scoresheet by the experimenter, and subsequently the total number of words reported across all tracks for each participant was calculated, for real and illusory words separately. If a particular word was reported more than once by a participant it was only scored once.

2.4.3 Anomalous experiences and paranormal attributions

An amended version of the 20-item SAE (Irwin et al., 2013) was used as a measure of the number of separate types of anomalous experiences that a person had had. Three items that were not clearly of anomalous experiences were removed (e.g., item 20, 'In magazines I read, the horoscope for my star sign usually turns out to be accurate.'), and some wordings were changed. The questionnaire thus referred to 17 different anomalous experiences, and participants responded concerning whether they had ever encountered each experience, and whether they considered the experience to have a paranormal explanation. For example, item 1 stated 'I have had a dream about something of which I was previously unaware, and subsequently the dream turned out to be accurate.' Response options for this item were 'Yes, and I think it was an instance of telepathy or ESP,' 'Yes, but it was probably just a coincidence or unwitting insight,' and 'No.' All further statements and responses followed a similar format. The number of times the first or second response options were chosen was summed, and referred to as the Anomalous Experiences score, and the number of times the first response (yes with paranormal explanation) was chosen was summed, and referred to as the Paranormal Attributions score.

2.5 Procedure

An information sheet was provided, which gave participants a brief explanation of what would be required of them. The study was titled 'Personality and Hearing,' the SPS and paranormal aspects of the investigation were not disclosed so as not to influence

participants' expectations. Participants then provided written informed consent. For the auditory task, the participants sat at a table with speakers, as described in section 2.3. The following instructions were provided: 'You will be presented with six different tracks, each lasting 2 minutes. If you hear any words or phrases, please could you say them out loud, as you hear them.' Once the auditory task was completed, the participants filled in the HSPS and the amended SAE.

2.6 Statistical analyses

Statistical analyses were conducted using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA). Correlations between the variables were conducted for the confirmatory and exploratory analyses using Spearman's rho, due to non-normal distribution of HSPS scores in the current study, as well as non-normal distribution of the total real words and total illusory words reported on the auditory task, and number of SAE Paranormal Attribution responses. A threshold of $p<.025$ was used for testing the correlations for hypotheses 1 and 2, as a correction for correlating HSPS with two measures of auditory performance. All other correlations were tested with threshold of $p<.05$. Sex differences were tested for and, although these differences were not significant, correlations were re-run with sex partialled out so as to check for robustness of results.

3. Results

3.1 Descriptive statistics

Table 1 displays the descriptive statistics for the variables: HSPS, total number of real and total number of illusory words heard on the auditory task, and total number of Anomalous Experience responses and total number of Paranormal Attribution responses on the SAE.

Table 1. Descriptive statistics for the variables: Highly Sensitive Person Scale (HSPS), HSPS dimensions Ease of Excitation (EOE), Aesthetic Sensitivity (AES), and Low Sensory Threshold (LST), total number of real and total number of illusory words heard on the auditory task, total number of Anomalous Experience responses and total number of Paranormal Attribution responses on the Survey of Anomalous Experiences (SAE).

	Mean	SD	Min	Max	Skewness	Kurtosis
HSPS	108.44	22.53	71	182	0.87	.96
EOE	53.52	9.69	34	79	0.22	-.15
AES	31.84	7.05	14	45	-0.01	-.28
LST	17.00	7.13	7	38	0.84	.52
Real Words	1.86	1.25	0	6	0.74	.92
Illusory Words	23.34	10.02	8	51	0.54	-.26
SAE Anomalous Experiences	8.28	3.32	1	15	-0.01	.66
SAE Paranormal Attributions	2.74	3.32	0	11	1.15	.34

Mann-Whitney U tests revealed there were no significant differences between males and females for HSPS score ($U = 301.5$, $p = .64$), total real words heard ($U = 234.5$, $p = .34$), total illusory words heard ($U = 250.5$, $p = 61$), SAE Anomalous Experience responses ($U = 282$, $p = .68$), and SAE Paranormal Attribution responses ($U = 301.5$, $p = .63$).

3.2 Testing hypotheses

Table 2 displays the correlation statistics between the HSPS, auditory, and SAE variables. For the first hypothesis, there was a significant correlation between HSPS score

and number of real words heard during the auditory task. Although there were no significant differences between males and females on these variables a partial Spearman's correlation was then run, partialling out sex, for which $r_s(47) = .41$, p = .004. For the second hypothesis, there was a non-significant correlation between HSPS score and pareidolia (number of illusory words heard). For the third hypothesis, HSPS score had significant correlations with number of SAE Anomalous Experience responses, and with number of SAE Paranormal Attribution responses. For the fourth hypothesis, pareidolia had significant correlations with number of SAE Anomalous Experience responses and number of SAE Paranormal Attribution responses. These four significant Spearman correlation co-efficients were unchanged when sex was partialled out.

Table 2. Spearman's rho values and *p* values of the correlations between HSPS, auditory, and SAE variables.

	HSPS		Real Words		Illusory Words	
	r_s	*P*	r_s	*p*	r_s	*P*
Real Words	.40	.004	-	-	-	-
Illusory Words	.17	.28	.004	.98	-	-
SAE Anomalous Experiences	.50	< .001	-.17	.23	.37	.008
SAE Paranormal Attributions	.29	.04	.15	.31	.30	.04

Note: All dfs = 48.

3.3 Non-hypothesized exploratory relationships

Table 2 reports that there were non-significant correlations between number of real words heard on the auditory task and SAE Anomalous Experience and Paranormal Attribution responses. Spearman's rho values for the non-hypothesized correlations with the three dimensions of the HSPS identified by Smolewska et al. (2006) are displayed in Table A.1 (Appendix A). Scores on each of the three dimensions of HSPS had non-significant correlations with total number of real words heard and total number of illusory words heard on the auditory task. Correlations between each of the three dimensions of HSPS and reported total number of Anomalous Experiences and total number of Paranormal Attributions were also non-significant.

Table A.1. Spearman's rho values and *p* values of the correlations between the three HSPS dimensions EOE, AES, and LST, and the auditory and SAE variables.

	EOE		AES		LST	
	r_s	*p*	r_s	*p*	r_s	*p*
Real Words	-.08	.57	.08	.56	-.15	.29
Illusory Words	.14	.35	.14	.35	-.10	.50
SAE Anomalous Experiences	-.04	.81	.27	.06	-.01	.92
SAE Paranormal Attributions	.06	.69	.01	.95	.02	.92

Note: All dfs = 48.

4. Discussion

4.1 Discussion of testing of hypotheses

The current investigation shows that sensory-processing sensitivity (SPS), as measured by the HSPS, is associated with the recognition of degraded auditory stimuli. This finding of an objective perceptual advantage for individuals high in SPS complements and extends previous work showing brain, cognitive, and emotional response correlates of SPS. Importantly, SPS was not associated with reporting illusory perceptions, further supporting the conclusion that HSPs have a true sensitivity to real, genuine stimuli.

This relationship of SPS to the identification of degraded stimuli could be due to the deeper processing characteristic of SPS. Greven et al. (2019) raise the question of how information processing and emotional reactivity are associated with each other in SPS. They consider whether top-down influences such as deeper cognitive processing, attention, or high emotional reactivity, are primary components, or that more bottom-up influences are primary, such as reduced filtering of sensory information. The latter would result in increased awareness of environmental subtleties, and thus greater emotional and cognitive processing of the sensory information. They suggest that these top-down and bottom-up possibilities may be distinguished using perceptual tasks, such as illusions, and psychophysics. The current finding of SPS being related to recognition of degraded stimuli, but not to the illusory misperception of stimuli, supports a reduced filtering of sensory information account of SPS. However, other research questions and methods may address possible top-down components, and it is important to note that such a reduced filtering account is inconsistent with the finding of a lack of association between degraded stimuli detection and LST. Further theoretical considerations are also now needed on whether top-down and bottom-up models would differ in predictions of SPS having an association

(positive, negative, or none) with pareidolia. Replication of the current finding of no association between SPS and pareidolia is also needed, including with the testing of pareidolia in different modalities.

Whereas HSPS overall score was related to degraded stimulus perception this was not true for any of the three HSPS dimensions proposed by Smolewska et al. (2006). Although this finding may be due to the reduced possible range of scores within each dimension compared to the full scale, the negligible size of the correlation coefficients for the three dimensions found in the current study (rhos = -.08, .08, -.15; Table A.1) indicates that it is only the full scale that captures the range of characteristics of SPS that entail a relationship with sensitivity to degraded stimuli. The results thus favor Aron and Aron (1997) and Aron et al.'s (2012) claim that the HSPS is a unidimensional scale. Nevertheless, as there is debate about the type and number of such proposed dimensions, the association between such dimensions and the detection of degraded stimuli should be addressed in future research.

Regarding the secondary aim of the study, it was found that SPS is related to the reported frequency of anomalous experiences and paranormal attributions. This is supportive of the previous literature and further supports the validity of the HSPS. In addition, relationships were found between the behavioral measure of auditory pareidolia and the number of anomalous experiences and paranormal attributions reported, again suggesting that some individuals show a proneness to anomalous experiences and to interpreting ambiguities in their environment as paranormal. These associations of anomalous experiences and paranormal attributions with auditory pareidolia have not been found previously.

4.2 Practical implications of the SPS perceptual advantage finding

A practical consequence of the SPS perceptual advantage finding is that this can be used to show to clients in psychotherapy, and the lay public, that high SPS is not a weakness, deficit, or disability. Being able to explain that high and low SPS are each adaptive is especially important given that the proportion of clients in psychotherapy who have high SPS is greater than the proportion of high SPS individuals in the general population (Aron, 2010). This is also important in meeting Aron et al.'s (2012) aim of describing to professions involved with education, vocational choice, and assignment of roles in organizations, the positive aspects of SPS and the differentiation of SPS from more well-known traits such as neuroticism and shyness.

4.3 Limitations on generalizability

The study was conducted on a range of people living or working in XXXXXXX. All were Caucasian. Whereas the HSPS has been translated into languages other than English (e.g., German: Konrad & Herzberg, 2019) and has been researched in many countries, further research is needed to ascertain whether the correlation of degraded stimulus detection with the overall unidimension, but not with the EOE, AES, and LST dimensions, can be replicated elsewhere, including as part of confirmatory factor analytic investigations of the HSPS. Importantly, Aron (2010) considers that some cultures (e.g., Chinese, Japanese, European) might value HSPs more than what she terms pioneer cultures (e.g., USA, Australia). Addressing such possible cross-cultural differences in self-ratings and other-person attributions of SPS and HSPs are important in investigating the generalizability of the current findings.

5. Conclusion

Part of the definition and measurement of SPS and of HSPs is that the latter show a proneness to deep processing and reacting to subtleties in their internal and surrounding

environments. We confirm here through an objective behavioral measure the relationship of high SPS to the accurate detection of subtle, degraded stimuli. However, SPS is not related to the misperception of patterns in ambiguous signals (pareidolia), signifying that it is related to the true recognition of stimuli rather than susceptibility to misperception and response fluency. This demonstration of a perceptual advantage will be useful for public understanding of SPS and HSPs. Future research should address the generalizability of this finding of perceptual advantage to other modalities, such as detecting alterations in vibration on the skin, and spatial and visual acuity. Higher frequency of reporting anomalous experiences and paranormal attributions is also associated with SPS and with susceptibility to pareidolia, demonstrating a perceptual sensitivity bias in individuals with these anomalous experiences.

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References

Aron, E. N. (2010). *Psychotherapy and the highly sensitive person* (1st ed.). East Sussex, England: Taylor & Francis Group.

Aron, E. N., & Aron, A. (1997). Sensory-processing sensitivity and its relation to introversion and emotionality. *Journal of Personality and Social Psychology, 73,* 345-368. doi:10.1037/0022-3514.73.2.345

Aron, E., Aron, A., & Davies, K. M. (2005). Adult shyness: The interaction of temperamental sensitivity and an adverse childhood environment. *Personality and Social Psychology Bulletin, 31*, 181-197.

Aron, E. N., Aron, A., & Jagiellowicz, J. (2012). Sensory Processing Sensitivity: A review in the light of the evolution of biological responsivity. *Personality and Social Psychology Review*, *16*, 262–282. doi:10.1177/1088868311434213

Acevedo, B.P., Aron, E., Aron, A., Sangster, M., Collins, N., & Brown, L. (2014). The highly sensitive brain: An fMRI study of sensory processing sensitivity and responses to others' emotions. *Brain and Behavior, 4*, 580-594. doi:10.1002/brb3.242

Blagrove, M., French, C.C., & Jones, G. (2006). Probabilistic reasoning, affirmative bias and belief in precognitive dreams. *Applied Cognitive Psychology*, *20,* 65-83. doi:10.1002/acp.1165

Carr, M., Konkoly, K., Mallett, R., Edwards, C., Appel, K., & Blagrove, M. (2021). Combining pre-sleep cognitive training and REM-sleep stimulation in a laboratory morning nap for lucid dream induction. *Psychology of Consciousness: Theory, Research, and Practice*, *8* (in press). doi:10.1037/cns0000227

Carr, M., & Nielsen, T. (2017). A novel susceptibility framework for the study of nightmares: evidence for trait sensory processing sensitivity. *Clinical Psychology Review, 58*, 86-96. doi:10.1016/j.cpr.2017.10.002

Carr, M., Matthews, E., Williams, J., & Blagrove, M. (2020). Testing the theory of Differential Susceptibility to nightmares: The interaction of Sensory Processing Sensitivity with the relationship of low mental wellbeing to nightmare frequency and nightmare distress. *Journal of Sleep Research, 29,* e13200. doi:10.1111/jsr.13200

Chalup, S. K., & Hong, K. (2010). Simulating pareidolia of faces for architectural image analysis. *International Journal of Computer Systems and Industrial Management Applications, 2,* 262-278.

Clancy, S. A., McNally, R. J., Schacter, D. L., Lenzenweger, M. F., & Pitman, R. K. (2002). Memory distortion in people reporting abduction by aliens. *Journal of Abnormal Psychology, 111*, 455-461. doi:10.1037//0021-843x.111.3.455

Deutsch, D. (2003). *Phantom Words and Other Curiosities*. La Jolla: Philomel Records.

Deutsch, D. (2019). *Musical Illusions and Phantom Words: How Music and Speech Unlock Mysteries of the Brain.* Oxford University Press.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.G. (2009). Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behavioral Research Methods, 41,* 1149-60.

Gerstenberg, F.X.R. (2012). Sensory-processing sensitivity predicts performance on a visual search task followed by an increase in perceived stress. *Personality and Individual Differences, 53,* 496–500. doi:10.1016/j.paid.2012.04.019

Greven, U. C., Lionetti, F., Booth, C., Aron, E. N., Fox, E., Schendan, H. E., Pluess, M., Bruining, H., Acevedo, B., Bijttebier, P., & Homberg, J. (2019). Sensory processing

sensitivity in the context of environment sensitivity: A critical review and development of research agenda. *Neuroscience & Biobehavioral Reviews, 98,* 287-305. doi:10.1016/j.neubiorev.2019.01.009

Grimen, H. L., & Diseth, A. (2016). Sensory processing sensitivity: factors of the highly sensitive person scale and their relationship to personality and subjective health complaints. *Perceptual and Motor Skills, 123*, 637-653. doi:10.1177/0031512516666114

Hofmann, S. G., & Bitran, S. (2007). Sensory-processing sensitivity in social anxiety disorder: relationship to harm avoidance and diagnostic subtypes. *Journal of Anxiety Disorders, 21,* 944-954. doi:10.1016/j.janxdis.2006.12.003

Irwin, H. J., Dagnall, N., & Drinkwater, K. (2013). Parapsychological experience as anomalous experience plus paranormal attribution: a questionnaire based on a new approach to measurement. *Journal of Parapsychology, 77,* 39-53.

Irwin, H. J., Schofield, M. B., & Baker, I. S. (2014). Dissociative tendencies, sensory processing sensitivity and aberrant salience as predictors of anomalous experiences and paranormal attributions. *Journal for the Society of Psychical Research*, *78,* 193-206.

Jagiellowicz, J, Aron, A., & Aron, E. (2016). Relationship between the temperament trait of sensory processing sensitivity and emotional reactivity. *Social Behaviour and Personality: An International Journal, 44*, 185-199. doi:10.2224/sbp.2016.44.2.185

Jagiellowicz, K., Xu, X., Aron, A., Aron, E., Cao, G., Feng, T., & Weng, X. (2011). The trait of sensory processing sensitivity and neural responses to changes in visual scenes. *Social Cognitive and Affective Neuroscience*, *6,* 38-47. doi:10.1093/scan/nsq001

Jawer, M. (2006). Environmental sensitivity: Inquiry into a possible link with apparitional experience. *Journal of the Society for Psychical Research, 70*, 25-47.

Konrad, S., & Herzberg, P. Y. (2019). Psychometric properties and validation of a German High Sensitive Person scale (HSPS-G). *European Journal of Psychological Assessment, 35*, 364-378. doi:10.1027/1015-5759/a000411

Lange, R., & Houran, J. (1998). Delusions of the paranormal: a haunting question of perception. *Journal of Nervous & Mental Disease, 186,* 637-645.

Meyerson, J., Gelkopf, M., Eli, I., & Uziel, N. (2020). Burnout and professional quality of life among Israeli dentists: the role of sensory processing sensitivity. *International Dental Journal, 70*, 29-37. doi:10.1111/idj.12523

Nees, M. A., & Phillips, C. (2015). Auditory pareidolia: effects of contextual priming on perceptions of purportedly paranormal and ambiguous stimuli. *Applied Cognitive Psychology, 29,* 129-134. doi:10.1002/acp.3068

Pluess, M. (2015). Individual differences in environmental sensitivity. *Child Development Perspectives, 9*, 138-143. doi:10.1111/cdep.12120

Riekki, T., Lindeman, M., Aleneff, M., Halme, A., & Nuortimo, A. (2013). Paranormal and religious believers are more prone to illusory face perception than skeptics and non-believers. *Applied Cognitive Psychology, 27,* 150-155. doi:10.1002/acp.2874

Smolewska, K. A., McCabe, S. B., & Woody, E. Z. (2006). A psychometric evaluation of the highly sensitive person scale: The components of sensory-processing sensitivity and their relation to the BIS/BAS and “Big Five”. *Personality and Individual Differences*, *40*, 1269–1279. doi:10.1016/j.paid.2005.09.022

van Elk, M. (2015). Perceptual biases in relation to paranormal and conspiracy beliefs. *PLoS ONE, 10*(6): e0130422. doi:10.1371/journal.pone.0130422

Wilson, K., & French, C.C. (2006). The relationship between susceptibility to false memories, dissociativity, and paranormal belief and experience. *Personality and Individual Differences, 41,* 1493-1502.