

Sensory Processing Sensitivity: The State of the Model

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Outline

- The concept and its measurement
- SPS as a moderator of the effects of childhood environment ("differential susceptibility")
- Behavior/mood experiments
- Neural correlates
- Genetic correlates
- Some other studies of interest
- Summary

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What is Sensory Processing Sensitivity?

- Preference to process information more thoroughly
- Aware of subtle stimuli, easily over stimulated
- Greater emotional reactivity (both positive and negative)
- More responsive to environment ("vantage sensitivity"; "differential susceptibility")

Two Strategies

Two strategies: In over 100 species (Wolf et al., 2008, *PNAS*)

“Do it once and do it right”
versus
“Go for it; if wrong, go for it again”

That is:

Responsive, reflective, reactive, sensitive
versus
Nonresponsive, impulsive, low reactivity, non-sensitive

The Two Strategies

- **Animal research examples:**

- Fruit flies—sitters vs. rovers, neural complexity
- Pumpkinseed sunfish—bold vs. timid; or responsive vs. not responsive
- Primates—Uptight vs. laid back, actually more and less responsive

Probably Negative Frequency Dependent

(Wolf et al., 2008)

- Always a minority because no advantage if everyone were sensitive
 - For example: No advantage to a short cut through traffic if everyone uses it.

History of Development of the Concept

(Aron & Aron, 1997, *JSPS*)

- Was it introversion?
- Interviews
- Relation to infant temperament research
- Relation to animal research
- Why the need for a new term
- Highly Sensitive Person (HSP) Scale

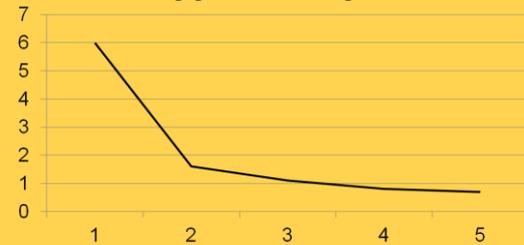
Example items from the HSP Scale

(Aron & Aron, 1997, *JPSP*)

- Do you seem to be aware of subtleties in your environment?
- Are you easily overwhelmed by things like bright lights, strong smells, coarse fabrics, or sirens close by?
- Do you have a rich, complex inner life?
- Are you deeply moved by the arts or music?
- Do you find it unpleasant to have a lot going on at once?
- Do changes in your life shake you up?

Reliability and factor structure

- Alphas for 27 item scale range from about .65 to .90 across multiple studies
- * Using standard scree test method, nearly all studies suggest a single factor solution



Possible facets

- In most studies scree test finds a one factor solution, but eigenvalue >1 rule or forcing multi-factor solutions can yield interesting results
- Most studies emphasizing facets focus on 3-factor solutions (and when we force a 3-factor solution we also find similar facets) generally like Smolewska et al's
 - **EA**: Ease of excitation (e.g., "... changes in your life shake you up")
 - **LST**: Low sensory threshold (e.g., "... made uncomfortable by loud noises.")
 - **AS**: Aesthetic sensitivity (e.g., "... aware of subtleties in your environment")
- Evans & Rothbart's 2 factor solution to match theoretical rationale:
 - **E&R's Negative affect** = EA & LST
 - **E&R's Orienting sensitivity** = AS
- Issues with factor analysis of HSP Scale
 - Distribution non-normal (possibly 80-20 taxon)
 - Theoretically SPS may be a causal indicator variable
 - Possible confounds with negative affectivity

Distinctiveness from Introversion and Neuroticism (Aron & Aron JPSP, 1997, Study 2)

	<u>r</u>	<u>R</u>	<u>pr</u>	<u>pR</u>
	HSP	I & N	HSP I&N	I&N HSP
Daylight sensitivity	.32	.27	.26	.12
Alcohol sensitivity	.39	.24	.36	.09
Time alone	.22	.32	.02	.29
Feelings well up	.28	.38	.11	.28

Importance of Controlling for Negative Affect (Neuroticism)

- HSP Scale has many negative items (on over-stimulation)
- Answer yes for two reasons: Sensitivity or negative affect
- When not controlling for negative affect, SPS as measured by standard HSP Scale often correlated with difficulties

Possibly a Category, Not a Dimension

Taxometric analysis distinguishes continuous from categorical variables. Using this method:

- Woodward et al. (2000) found the related trait of “reactivity” assessed in sample of 599 four-month-old infants to be categorical applying to about 10%
- Borries (2012), using multiple analysis methods with the HSP Scale in a large diverse sample of German adults ($N = 898$, $M_{age}=36$), converged on 15-20% were HSPs.

Borries conclusion:

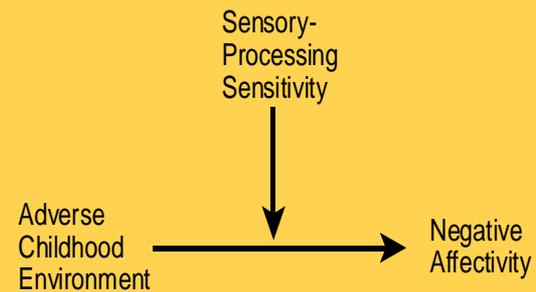
“HSPs exist, forming an independent group of people who are qualitatively distinct from all the others concerning their way to perceive and process stimuli”

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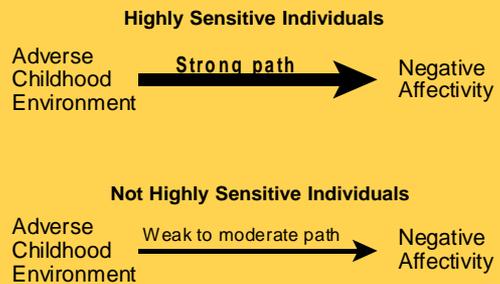
Does SPS Moderate Effects of Childhood Environment on Negative Affectivity?

Tentative Moderation Model



(Aron et al., *PSPB*, 2005)

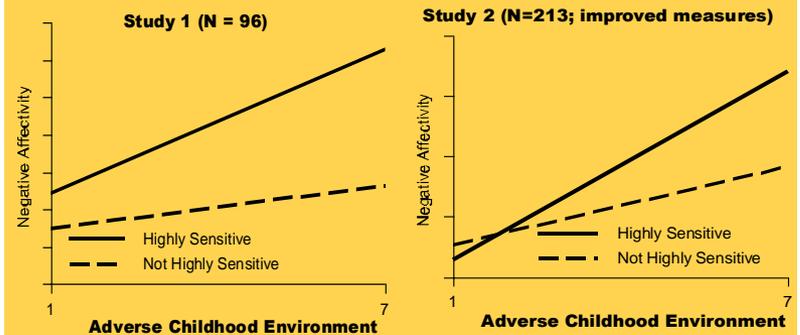
Tentative Moderation Model (another illustration)



(Aron et al., PSPB, 2005)

Some Supporting Evidence for Moderation

(Aron et al., PSPB, 2005)



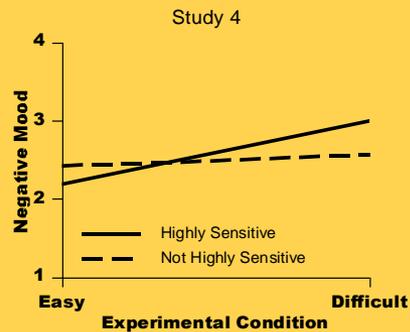
*Note: Any negative bias by HSPs in recall of childhood environment would lead to opposite effects of those found here. (That is, high NA HSPs are actually reporting **less** adverse childhoods than equally high NA nonHSPs.)*

(Basic result replicated by Liss et al., 2005)

Some Experimental Evidence

(Aron et al., *PSPB*, 2005, Study 4)

- N = 160
- Brief HSP Scale
- All completed supposed standard questionnaire
- Start & end assessed negative mood
- In middle, either very easy or very difficult “Applied Reasoning Ability” test



Differential Susceptibility

(Belsky & Pluess, 2009; Ellis et al., 2011)

- Challenges previous widely-held assumption:
 - SPS (and other low frequency temperaments) is NOT only a vulnerability factor
- Meta-analysis:
 - A number of susceptibility indicators (including SPS):
 - Behavioral (e.g., “irritable” infants)
 - Genetic (e.g., ss allele)
 - Physiological reactivity (Boyce)
 - HSP Scale
 - Under right conditions (“goodness of fit”), SPS is an advantage

Vantage Sensitivity

Pluess & Belsky (2013, *Psych Bulletin*; after Manuck, 2011)

- Focuses on the “for better” half of interaction
- Refers to general rather than specific advantage
- “Resilience” equals vantage resistance
- Well known first study: Suomi (1997), “up tight” rhesus monkeys assigned skilled mothering = higher social status than “laid back” monkeys

Examples of Vantage Sensitivity

- UK resilience-promoting intervention, only benefited upper 1/3 on HSP Scale
- Maternal responsiveness = moral internalization only with ss allele
- BEI: Rumanian orphan infants randomly assigned to skilled foster care: only those with ss allele benefited at 54 mos
- Adults: ss allele. Amplifies positive emotion in marriage and amplifies social emotions in general

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Laboratory Visual Search Task

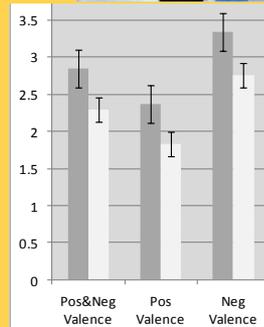
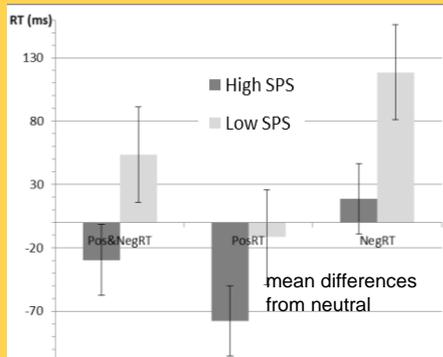
- On a standard visual search task, SPS associated with better performance (faster response time and fewer errors), followed by increased perceived stress (Gerstenberg, 2012).

Correlations with HSP Scale (controlling for N & E)

<u>RT_{sum}</u>		<u>Error_{sum}</u>		<u>Tension_{T2-T1}</u>	
t	β	t	β	t	β
-7.56	-0.72**	-2.60	-.32**	2.07	.27*

Response to Emotional Pictures

SPS associated with faster and more strongly valenced response to both positive and negative images (Jagiellowicz, Aron, & Aron, 2013)



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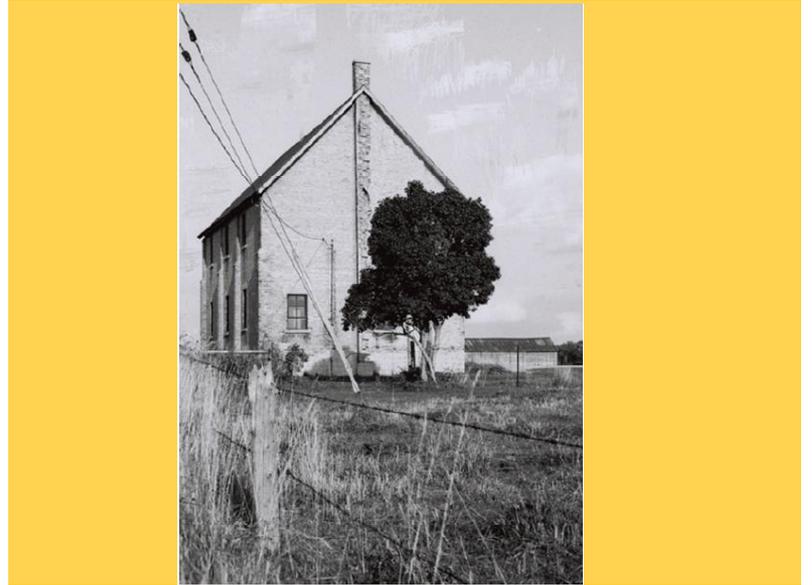
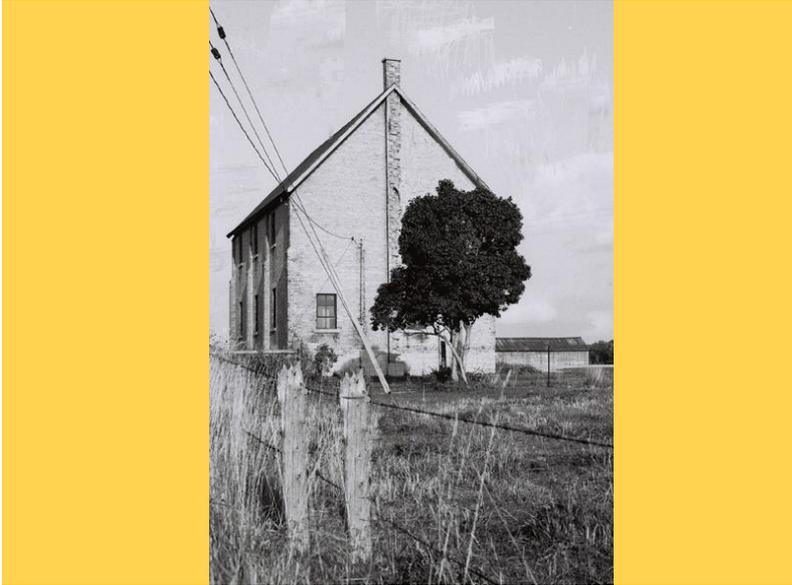
Neural Correlates

- More activation making fine visual distinctions (Jagiellowicz et al., 2010)
- Reduced effect of cultural differences in brain response during visual judgment tasks (Aron et al., 2010)
- Greater neural response to positive and negative images (Jagiellowicz, 2012)
- Greater neural response to both sad and happy emotional states of others especially in insula and mirror neurons (Acevedo et al., 2014)
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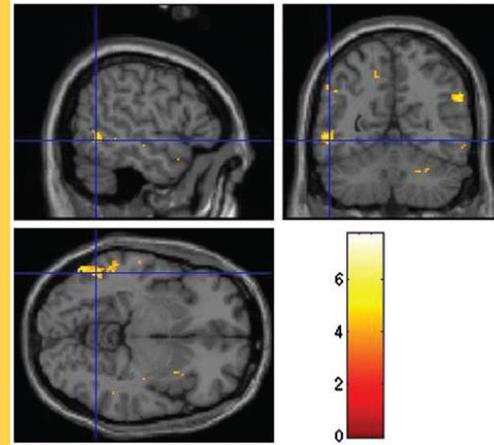
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Brain Activation Minor vs. Major Scene Changes

- HSP Scale scores correlated with greater activation in response to minor changes (vs. major changes) in
 - Secondary visual areas
 - Visual association areas
 - Visual-motor coordination areas
- Results remain (and stronger) controlling for neuroticism and extraversion



Example: Left middle temporal gyrus (MNI: -52, 56, 6)
SPS residual association for minor > major change

Neural Correlates

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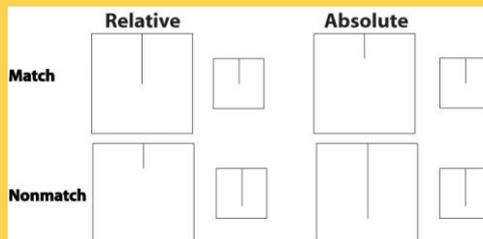
Background from many previous studies

- Interdependent cultures (e.g., East Asians) perform better incorporating context
- Independent cultures (e.g., Americans) perform better ignoring context
- Applies to both social relations and simple perceptual judgments

Culture & Brain Response to Basic Visual Judgments

(Hedden et al., *Psych Science*, 2008)

- 10 East Asians recently in U.S.
- 10 Americans of European descent
- fMRI scan while making judgments of size of line in a box
 - Some judgments **relative** - require attending to context (box size)
 - Some judgments **absolute** - require ignoring context

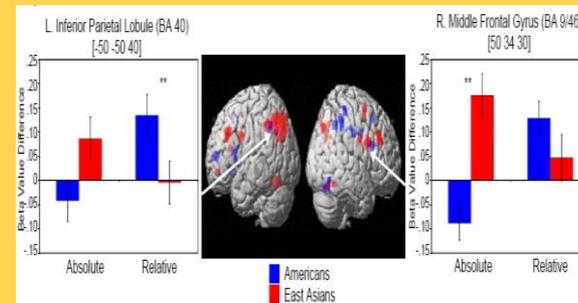


Culture & Brain Response to Basic Visual Judgments

(Hedden et al., *Psych Science*, 2008)

Brain system (from parietal regions) known to be engaged during attentionally demanding mental tasks

- was more active for East Asians during judgments ignoring context
- was more active for Americans during judgments attending to context



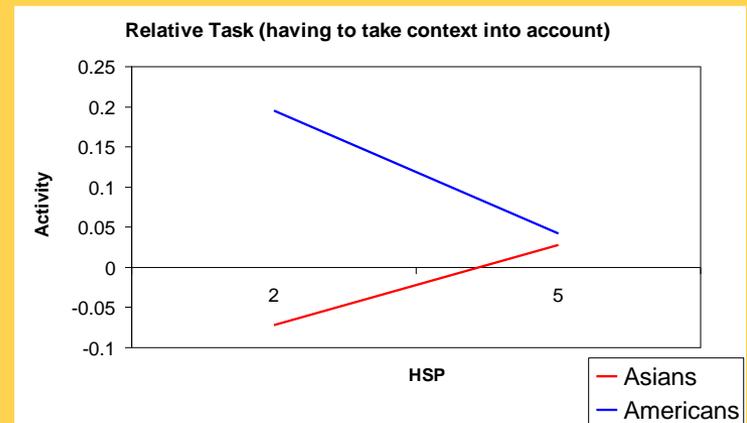
Relation to SPS

Hypothesis:

Highly sensitive individuals, because they process information more deeply, should be less affected by cultural context when making direct visual judgments

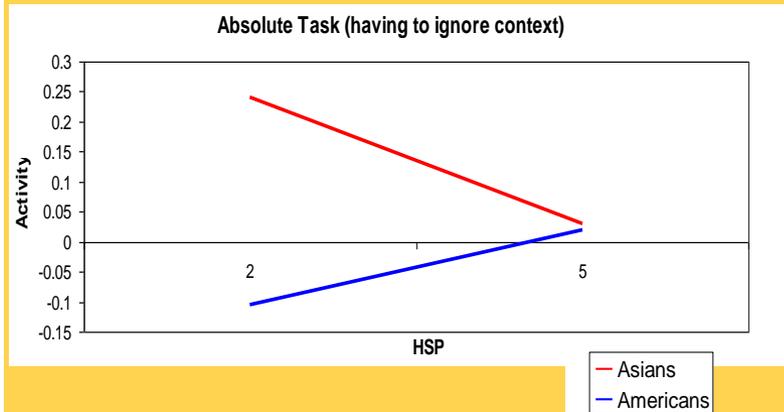
Results

(Aron et al., 2010, SCAN)



Results (continued)

(Aron et al., 2010, SCAN)



Neural Correlates

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Response to positive & negative images

- Compared to low SPS, high SPS (controlling for E and N):
 - more activation of emotional processing areas (but not amygdala)
 - more activation for positive pictures (in basal ganglia), much like what is typically found for extraversion
 - more elaborated perceptual processing generally (replicating previous studies)
- Hence, more positive appraisal of incoming stimuli may partially motivate elaborated processing and explain vantage sensitivity effects

Neural Correlates

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Greater neural response to emotional states of others, especially partners

(Acevedo et al., 2014, *Brain & Behavior*)

- 18 newly marrieds scanned while viewing photos of partner and of strangers displaying positive, negative, or neutral facial expressions.
- SPS associated with stronger neural activation in response to others' positive and negative (vs. neutral) emotional expressions in regions involved in awareness, empathy, unconscious preparation to act, and meaning-making (e.g., premotor area, cingulate, AI, IFG, and MTG)
- Results significantly even stronger for partners (& to positive stimuli) in regions involved in empathy, awareness, self-other processing, and reward

Partner Happy-versus-Stranger Happy



Partner Sad-versus-Stranger Sad contrast



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Genetic Correlate: Serotonin

- **Three types of genetic variation: 5-HTTLPR short/short, short/long, and long/long genotype**
- **s/s inconsistently associated with negative affect, esp. depression**
- **Inconsistent results may be due to those with ss allele who had good childhood environments were not depressed and may even have better mental health than others**

Associated with SPS

(Licht, Mortensen, Arentzen, Norremolle, & Knudsen, 2011)

- 168 healthy volunteers
- 5-HTTLPR s/s genotype was associated SPS, controlling for age, gender, psychological distress, and Neuroticism. Relationship strengthened with inclusion of Openness to Experience and Extraversion were included ($pr=.21$, $p=.01$)
- Combined 5-HTTLPR/rs25531 s/s & s/l genotypes also associated with SPS

New Understanding of Serotonin s/s and s/l genotype

- Important variable in differential susceptibility meta-analysis and vantage sensitivity (Pluess & Belsky, 2012)
- Review found surprising “superior performance on an array of cognitive tasks” (Homberg & Lesch, 2011)
- Not more responsive to negative valenced words, as thought (Roiser, Rogers, Cook, & Sahakian, 2006)
- Better gambling decisions—more responsive to opportunities and risk (perception plus emotion; Roiser, Rogers, Cook, & Sahakian, 2006)
- More sensitive to social cues (Taylor et al, 2006, benefit more from social support)
- SPS-culture fMRI result also true for s/s allele subjects (Kim et al, 2010)

Serotonin Studies with Rhesus Monkeys

- Only other primate species with this allele (s/s and l/l only)
- Similar “broadly superior performance” on a variety of decision-making tasks (Jedema, et al., 2009)
- May explain ability, similar to humans, to adapt to widely varied environments

Genetic Correlate: Dopamine

(Chen et al., 2011, *PlosOne*)

- Previously lower than expected association of personality traits with genetic variations in twin studies
- Chen et al. studied all 98 genes with dopamine polymorphisms
- Chose SPS because it seems “deeply rooted in the nervous system”
- 10 loci on 7 genes yielded expected levels trait-genetic associations
- All alleles effective only through interacting with others in the set; little known about these alleles

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Some other studies of Interest

- Romantic Relationships
 - more easily bored (Aron et al., 2010)
 - different sexual behavior (ex., less interest in variety, fewer bad experiences (Aron, 2006)
 - Spouse's pre-talk affect -> own change (Schoebi et al., 2011)
 - Marital satisfaction over 13 years (Haase et al., 2013)
- Parenting
 - Perceive home as more chaotic (Wachs, 2012)
 - See selves as more creative & connected but also as more stressed (Aron & Aron, in prep)
- Work Place (analyses not controlling for negative affect)
 - More affected by stress (Evers, Rasche, & Schabracq, 2008)
 - Lower well being, but supervisors rated their performance higher (Bhavani, 2011)

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