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Sensory processing sensitivity and serotonin gene variance: Insights into mechanisms shaping environmental sensitivity

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ABSTRACT

Current research supports the notion that the apparently innate trait Sensory Processing Sensitivity (SPS) may act as a modulator of development as function of the environment. Interestingly, the common serotonin transporter linked polymorphic region (5-HTTLPR) does the same. While neural mechanisms underlying SPS are largely unknown, those associated with the 5-HTTLPR have been extensively investigated. We perform a comparative analysis of research findings on sensory processing facets associated with the trait and polymorphism to: 1. detect shared phenotypes and frame a hypothesis towards neural mechanisms underlying SPS; 2. increase the understanding of 5-HTTLPR-associated behavioral patterns. Trait and polymorphism are both associated with differential susceptibility to environmental stimuli; additionally, both involve 1. having stronger emotional reactions, 2. processing of sensory information more deeply, 3. being more aware of environmental subtleties, and 4. being easily overstimulated. We discuss neural mechanisms and environmental conditions that may underlie these four facets. Besides urging the actual assessment of the link between the two, the conclusions of our analyses may guide and focus future research strategies.

Contents

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1. Introduction

The personality trait of sensory processing sensitivity in humans (SPS (Aron and Aron, 1997)) is characterized by being more sensitive to subtle stimuli, and employing deeper or more complex processing strategies for planning effective action and later revising cognitive maps, all of which is driven by stronger emotional reactions, both positive and negative. Whereas SPS is a psychological concept, there is evidence that it has biological foundations and neural correlates. For example, evolutionary biology has yielded evidence that in over 100 nonhuman species (e.g., goats (Lyons et al., 1988), pigs (Hessing et al., 1994), rats (Coppens et al., 2010), fish (Schjolden and Winberg, 2007)), variations in responsivity, reactivity, flexibility, or sensitivity to environmental stimuli exist between individuals (Dingemanse et al., 2010; Wolf et al., 2008). As for neural correlates, functional magnetic resonance imaging (fMRI) studies in human SPS trait carriers have revealed differences from noncarriers in brain activation within areas involved in attention, awareness, and information processing of social and nonsocial stimuli (see Section 4). Although a broadly focused review of the biological substrate of environmental sensitivity in humans has been attempted (Moore and Depue, 2015), the neur(on)al mechanisms underlying SPS are still poorly understood and need further clarification for appropriate use of the trait in prevention and treatment of aberrant developmental process and associated disorders.

Individual temperament differences in reactivity to the environment are widely studied in children (Belsky et al., 2009; Ellis et al., 2011), and accordingly SPS or very similar conceptualizations have been proposed to be genetically determined traits (Belsky et al., 2009; Ellis et al., 2011), although epigenetic and perinatal contributions cannot be excluded. In particular, SPS has been tentatively associated with the short (s) low-expressing allelic variant of the serotonin transporter linked polymorphic region (5-HTTLPR) (Licht et al., 2011). We believe that this association deserves further exploration, since the known neural mechanisms of the 5-HTTLPR s-allele make it possible to frame a hypothesis towards understanding the neur(on)al mechanisms underlying SPS. Furthermore, a comparison between the trait and the allele increases the understanding of the environment-driven behavioural patterns displayed by those carrying the 5-HTTLPR s-allele.

A frequent critique is that common gene variants bring only small effect sizes to traits. True, it is most likely that SPS is shaped by an array of genetic factors. A recent review of Moore and Depue (2015) discusses the potential involvement of several neurotransmission (dopamine, GABA, norepinephrine, serotonin) and neuropeptide (opiates, oxytocin, corticotropin-releasing hormone) systems in environmental reactivity. While effective in moving towards an understanding of the array of genetic factors shaping SPS, we believe that in order to better understand the neur(on)al mechanisms underlying SPS, it is especially effective to highlight one genetic factor as a start, one that is known to be involved and has been well studied. That is, when dealing with multiple genetic factors it is highly challenging to identify the common mechanistic denominator.

Of interest, both SPS and the 5-HTTLPR s-allele are well associated with greater sensitivity to environmental stimuli and are evolutionarily ancient (Dobson and Brent, 2013). Given that people scoring high on the Highly Sensitive Person (HSP) scale (Box 1) as well as 5-HTTLPR s-allele carriers (Karg et al., 2011; Caspi et al., 2010); but see (Risch et al., 2009) may be at risk for affective disorders when exposed to adverse environmental stimuli during childhood (Liss et al., 2005), we suggest that elucidating interrelations between specific trait and genotype effects and their neur(on)al mechanisms may in particular help to better define the environmental adversity that triggers psychopathologies in 5-HTTLPR s-allele carriers. It may also help to understand why not all methodologically sound studies find an association between the 5-HTTLPR s-allele and depression (Sharpley et al., 2014). Furthermore, the emphasis on this allele helps us to better understand specifically the neur(on)al mechanisms underlying individual differences in environmental sensitivity in children, that at a young age has been well studied as a behaviourally inhibited temperament (Kagan et al., 1987). Recent research (Davies et al., 2013) has found that somewhat later in childhood inhibited temperament can shape behavioural flexibility and advantageous adaptive behaviour in a negative social environment (internalizing rather than more dangerous externalizing behaviors), so that it was likened at this age to SPS. If environmental sensitivity is the largely invisible cognitive process underlying the observable behavioural inhibition, it may be necessary to revise the view of why at least some inhibited children behave in this way: Perhaps they are not necessarily afraid but may 'pause to check' in order to gather more information before taking action. Additionally, a deeper understanding of the cognitive processes of those with the allele may enhance our understanding of the seemingly inconsistent results among 5-HTTLPR gene x environment studies. If child carriers are simply absorbing information from their environments, both positive and negative, a failure to include positive early life experiences and measures of later positive characteristics in such studies may lead to overemphasis of the impact of adverse early life experiences. Furthermore, the relationship between SPS and the 5-HTTLPR is of high interest because both serve as predictor of treatment response in children, in the reduction of depression scores (Pluess and Boniwell, 2015; Brett et al., 2015). Finally, another potential value of this review is that it offers an introduction for those who may be more familiar with the s-allelic variant of the 5-HTTLPR than with SPS. SPS provides a phenotype that is fairly easily recognized in the population, and could provide a valuable clue to recognizing those most vulnerable to stress and to mood disorders. Thereby, insight into its neur(on)al mechanisms may advance the understanding of the pathology underlying mood disorders.

The idea of "HSPs" or highly sensitive people is also gaining increasing popularity (Aron, 1997), which may serve to create confusion or even alienation between mental health providers and their clients unless both sides understand SPS and its underlying neur(on)al mechanisms better. Whatever the actual genetic predispositions of SPS (another has been found; (Chen et al., 2011)), a broader discussion of the phenotype seems warranted at this time, without the delay for further replications.

Box 1: Highly Sensitive Person (HSP) scale.
The standard measure of SPS, the HSP Scale (Aron et al., 2012), contains 27 diverse yet fairly strongly interrelated items, varying from having a rich and complex inner life, and being conscientious and deeply moved by the arts and music, to being more shaken than others by changes in one's life, having more difficulty performing a task when being observed, startling easily, and being more sensitive to pain, hunger, and caffeine. It has been born out of interviews with adult persons self-identified as highly sensitive. The scale has been associated with differences in brain activation primarily in attentional and secondary perceptual regions in three fMRI studies (Jagiellowicz et al., 2011), (Acevedo et al., 2014), (Aron et al., 2010). Recently, also a child version of the HSP scale has been developed, adjusted to life experiences of children. Further explanation of how to use these adult and child scales can be found at: http://hsperson.com/research/measurement-scales-for-researchers/.