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SENSORY PROCESSING SENSITIVITY AND ATTENTIONAL BIAS – A PILOT STUDY

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Samenvatting: Despite the increasing interest in the construct of sensory processing sensitivity and the recent tendency in publications to include more objective measures, the underlying mechanisms that might be responsible for the differential information processing and heightened emotionality of individuals high in sensory processing sensitivity are still unclear. Supposedly, a higher awareness of both positive and negative subtle stimuli and a deeper processing thereof are the central characteristics of the construct. These might be driven by differences in the allocation of attention. To further explore these ideas, an emotional variant of the Posner exogenous cueing task was conducted. Participants classified as high in sensory processing sensitivity as well as controls were presented with neutral, happy, angry, and sad faces for durations of 200 ms and 1000 ms. Cue validity, engagement, and disengagement effects were analyzed. This allowed for an examination of processing differences for the various emotional valences at early (200 ms, indicative of a possible lower threshold to subtle stimuli) and later stages of attention (1000 ms, indicative of a deeper elaboration of information). Results revealed a significantly higher attentional engagement of the high SPS group for happy cues at the 1000 ms duration, indicating a continous directing of attention at the positive stimuli and a deeper processing of this material. This engagement was found despite the high SPS individuals' self-reported higher negative affect and lower extraversion, contradicting the findings of the questionnaires. Besides that, the high SPS group diverted attention away from neutral cues at 1000 ms, which could potentially be a strategy to prevent sensory overload. The results should be taken with caution however due to the small sample size and some needs for improvement that are discussed. Altogether, the current study showed that attentional bias research possesses good potential to further investigate sensory processing sensitivity.

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Abstract

Despite the increasing interest in the construct of sensory processing sensitivity and the recent tendency in publications to include more objective measures, the underlying mechanisms that might be responsible for the differential information processing and heightened emotionality of individuals high in sensory processing sensitivity are still unclear. Supposedly, a higher awareness of both positive and negative subtle stimuli and a deeper processing thereof are the central characteristics of the construct. These might be driven by differences in the allocation of attention. To further explore these ideas, an emotional variant of the Posner exogenous cueing task was conducted. Participants classified as high in sensory processing sensitivity as well as controls were presented with neutral, happy, angry, and sad faces for durations of 200 ms and 1000 ms. Cue validity, engagement, and disengagement effects were analyzed. This allowed for an examination of processing differences for the various emotional valences at early (200 ms, indicative of a possible lower threshold to subtle stimuli) and later stages of attention (1000 ms, indicative of a deeper elaboration of information). Results revealed a significantly higher attentional engagement of the high SPS group for happy cues at the 1000 ms duration, indicating a continous directing of attention at the positive stimuli and a deeper processing of this material. This engagement was found despite the high SPS individuals' self-reported higher negative affect and lower extraversion, contradicting the findings of the questionnaires. Besides that, the high SPS group diverted attention away from neutral cues at 1000 ms, which could potentially be a strategy to prevent sensory overload. The results should be taken with caution however due to the small sample size and some needs for improvement that are discussed. Altogether, the current study showed that attentional bias research possesses good potential to further investigate sensory processing sensitivity.

Sensory Processing Sensitivity and Attentional Bias – A Pilot Study

A Short Outlook

During the last few years, the phenomenon of sensory processing sensitivity has attracted increasing public and scientific interest and is slowly beginning to find its way into education and healthcare sectors. Individuals high in this trait perceive the world differently and are characterized by their intense emotionality, attention to detail and their strong capacity for empathy. They are able to perceive intricacies in their environment and subtle shifts in the moods of other people that less sensitive persons often miss out on, and are more easily aroused and moved by these subtleties. Many people can relate to what it means to have such a highly arousable and reflective nervous system and recognize the daily struggles that may often come along with it in our fast-paced society. At present, the functionality of sensory processing sensitivity and the way it interacts with environmental factors to lead to different developmental and psychological outcomes remains vague. Researchers involved in the study of sensory processing sensitivity have presumed that a lower threshold to notice subtle details as well as an enhanced elaboration of these details are the central characteristics of this construct.

Research that includes objective measures and tries to identify the underlying mechanisms that could be responsible for such a heightened sensitivity, however, is very scarce. A possible reason for absorbing more information from the surroundings and the higher receptiveness for emotions might lie in a different focusing of attention on (emotional) stimuli in sensory processing sensitivity. This could enhance the perception and further processing of the attended material. In order to expand the knowledge on sensory processing sensitivity, we will therefore introduce the concept into the field of attentional biases to emotional stimuli. Implementing the emotional variant of the Posner exogenous cueing task will allow for a deeper and more fain-grained investigation of possible differences in information processing between individuals with SPS and controls, whether these differences situate themselves at early, automatic and/or later, elaborative stages of attention, and whether this differential attention is of a general nature or somehow emotion-specific. The outcomes of this pilot study will hopefully provide first insights into the possible driving mechanisms behind sensory processing sensitivity and yield some guidelines, improvements and ideas that set the ground for larger studies to come.

Fundamentals of Sensory Processing Sensitivity

One of the most fundamental characteristics that distinguishes individuals may be their sensitivity, or the extent to which they are aware of and respond to stimulation from their surroundings. Aron and Aron (1997) have given this construct the name of sensory-processing sensitivity (SPS), which they consider an inherent, dichotomous trait that is present in about 20% of the population and that is clearly distinguishable from related constructs such as introversion, emotionality, behavioral inhibition or shyness (Aron & Aron, 1997). Individuals high in SPS are thought to be very conscientious, to have more intense emotions, to have a heightened perception of subtleties and to be more easily aroused by different environmental stimuli (Aron & Aron, 1997; Aron, Aron, & Davies, 2005). The trait is measured by means of the Highly Sensitive Person Scale (Aron & Aron, 1997), a standardized 27-item questionnaire that includes items such as "Are you easily overwhelmed by strong sensory input?", "Do other people's moods affect you?", "Do you become unpleasantly aroused when a lot is going on around you?", and "Do you notice and enjoy delicate or fine scents, tastes, sounds, works of art?" The higher awareness of stimulation of individuals with SPS is hypothesized to arise in part from to their lower threshold for stimulation, which can eventually lead to overarousal when in a very stimulating environment (Aron, Aron, & Jagiellowicz, 2012; Jerome & Liss, 2005), and in part because of their tendency to process incoming information more thoroughly (Aron & Aron, 1997; Aron et al., 2012).

While these researchers have only deduced the claim that SPS involves a lower threshold for stimulation from studies of related traits such as introversion, at least two fMRI studies on SPS may provide some evidence for a generally deeper form of elaboration and processing: In an additional analysis of the original study carried out by Hedden, Ketay, Aron, Markus, and Gabrieli (2008), Aron et al. (2010) examined brain activity of participants from Asia and the United States of America while doing a visuospatial task that asked them to either make context dependent or context independent judgements. As stimuli, different combinations of a vertical line inside a box were used that differed in size. Participants then had to judge whether the current box-line combination was proportionally equal to the previous combination (context dependent judgement) or whether only the current line matched the previous line, without considering the box (context independent judgement). For the culturally more difficult task (context dependent for Americans, context independent for Asians), a lower level of SPS was associated with higher activation in several frontal and parietal brain regions (e.g., the left middle frontal gyrus, the right inferior parietal lobule, and the right superior parietal lobe; Hedden et al., 2008) that indicate higher attentional effort (Aron et al., 2010). From that, the authors concluded that individuals with SPS do not need to spend as much effort to overcome cultural differences in perception because they process all stimuli more thoroughly, independent of the context (Aron et al., 2010). In the second study (Jagiellowicz et al., 2011), participants had to detect changes in landscape pictures. Changes could either be subtle (such as adding half a hay bale to a line of several hay bales in the background of the picture) or more obvious (e.g., adding a second post into a salient fence in the foreground of the image). When detecting subtle changes, individuals higher in SPS took longer to respond and showed increased brain activity in areas such as the right claustrum, the left middle temporal gyrus and the right subgyral temporal lobe that are involved in high-order visual processing and in integrating incoming visual information, indicating their higher attention and deeper processing of the subtle changes (Jagiellowicz et al., 2011). These two studies seem somewhat contradictory as the one deduces a deeper processing style from lower brain activity in SPS, while the other does the exact same based on stronger brain activation in SPS. The crucial cause for this argumentative difference lies in the different brain areas that were analyzed. It is indeed logical that heightened activation in high-order brain areas that are responsible for the integration of incoming information may hint at a more elaborative processing. The assumption that lower attentional effort in SPS in response to doing a more difficult task is necessarily a consequence of a more thorough processing however might be a little bit far-fetched and should be taken with more caution.

Possibly because individuals with SPS take more time to process information deeply, they are also thought to be characterized by a tendency to apply a behavioral strategy of pausing and thinking first before eventually acting in novel, unknown situations (Aron et al., 2012; Jerome & Liss, 2005). The last central component of SPS involves stronger emotional responses (such as feeling acute happiness or crying easily; Aron & Aron, 1997). This is hypothesized to result in increased processing, memory and learning from past emotional experiences (Aron et al., 2012).

SPS and Emotional Reactivity: Diathesis-Stress vs. Differential Susceptibility

Originally, Aron and Aron (1997) regarded SPS as a neutral trait that might lead to different developmental outcomes depending on its interaction with life history. As people carrying the trait are thought to be more aware and emotionally sensitive to both negative and positive environments, these authors argue that this should have a stronger impact on shaping individuals with

SPS' personality and affectivity in positive or negative ways. Despite this assumption, much of the research since then has focused on the negative aspects of SPS, considering the trait as a potential vulnerability factor. In general, authors that apply such a diathesis-stress framework (Zuckerman, 1999) or found support for it in their data theorize that individuals' high in SPS higher awareness of distressing information, their susceptibility to unpleasant overarousal and the resulting higher negative affectivity may render them more prone to unfavorable outcomes (e.g., Evers, Rasche, & Schabracq, 2008; Meyer, Ajchenbrenner, & Bowles, 2005). In the field of health for example, high SPS has been associated with neuroticism (Ahadi & Basharpoor, 2010; Smolewska, McCabe, & Woody, 2006), depression (Liss, Mailloux, & Erchull, 2008; Liss, Timmel, Baxley, & Killingsworth, 2005) and trait anxiety (Liss et al., 2005). SPS has also been related to symptoms of avoidant personality disorder and borderline personality disorder (Meyer et al., 2005; Meyer & Carver, 2000). In the only study that involved a clinical sample, Hofmann and Bitran (2007) examined participants diagnosed with social anxiety disorder and found a strong association of SPS with agoraphobic avoidance, harm avoidance and the generalized subtype of social anxiety disorder. Two other studies found SPS to be associated with a variety of physical symptoms (such as backpain, fatigue and nausea) and overall perceived stress (Ahadi & Basharpoor, 2010; Benham, 2006). And in the field of work, Evers, Rasche, and Schabracq (2008) found that SPS was related to higher work displeasure and need for recovery as well as a heightened feeling of alienation from work and a lower overall sense of coherence.

While it is certainly true that SPS may lead to adverse outcomes, relationships of SPS to ill-health are not necessarily as one-dimensional and direct as proposed by some diathesis-stress accounts. Brindle, Moulding, Bakker, and Nedeljkovic (2015) for example discovered that the relationship between SPS and depression was partly mediated by weaker emotion regulation strategies (such as negative outcome expectancies and the belief in one's own inability to regulate upsetting emotions), higher awareness and lower acceptance of internal aversive emotional states. Although these authors argue that SPS is causally related to those three variables, there is no clear evidence that SPS should directly undermine effective emotion regulation strategies or acceptance of emotions. It could also be argued that SPS may possibly interact with emotion regulation and acceptance in positive ways, thereby preventing negative outcomes. In this context, Bakker and Moulding (2012) have found that SPS only related to anxiety when acceptance and mindfulness where low, but not when these two variables where high.

Most importantly, in the first experimental study on the subject, Aron et al. (2005, Experiment 4) manipulated high and low SPS individuals by making them believe that they were doing exceptionally well or badly on an ability test. Individuals diagnosed as highly sensitive subsequently reported higher negative affect when they thought they had done poorly, but when they believed they had done well they reported a non-significant lower negative affect compared to respondents under the cutoff in SPS. Even though the study did not include positive emotion as a dependent measure, these results present evidence for the original argument (Aron & Aron, 1997) that SPS might comprise a higher reactivity not only to negative, but also to positive stimuli and environments. For these authors, it seems plausible from a purely logical point of view that such a fundamental characteristic would not automatically be related to negative outcomes, as "evolution should have eliminated such a disadvantageous trait" (Aron et al., 2012, p. 271).

Research on SPS following this line of thought is closely related to the differential susceptibility hypothesis (Belsky, 1997) and the concept of biological-sensitivity-to-context (Boyce & Ellis, 2005) that arose from the field of evolutionary biology. Although these two models differ in how much emphasis they put on the influence that nature and nurture have on sensitivity, they both state that individuals may fundamentally differ in their plasticity or sensitivity in response to environmental influences (Belsky & Pluess, 2009). This sensitivity may render individuals more aware of both opportunities and risks within their environment and prepare them to react accordingly (Ellis, Boyce, Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2011). Highly susceptible individuals may thus benefit more from supportive environments (e.g., high-quality care and parenting), but at the same time are more negatively influenced by stressful environments (e.g., threatening childhood events and poor-quality parenting; Boyce & Ellis, 2005). Seen that way, the trait of high susceptibility or sensitivity to context implies a stronger capacity to adapt to environmental changes, which is theorized to be an evolutionary advantage that may enhance reproductive fitness of a species (Ellis et al., 2011) as long as only a minority of the population carries such an advantageous trait (Wolf, van Doorn, & Weissing, 2008). Up to this point, genetic research has identified several plasticity markers that lead to crossover interactions with the environment (for an overview, see Belsky & Pluess, 2009). SPS has been found to be associated with some of them, that is with the short allele of the serotonin transporter polymorphism (5-HTTLPR; Licht, Mortensen, & Knudsen, 2011) and with multiple polymorphisms within the dopamine system (Chen et al., 2011).

Besides this indirect evidence and the study by Aron et al. (2005) mentioned above, only few studies have found direct support for the claim that SPS may also involve a higher susceptibility to positive events or stimuli. Pluess and Boniwell (2015) for example examined the effects of a school-based depression prevention program on a sample of eleven-year-old girls from an at-risk population. At the twelve-month follow-up assessment, highly sensitive girls (the highest scoring quartile on SPS) that were in the treatment group reported significantly lowered depression scores, while this was not the case for controls (the lowest scoring quartile). It was theorized that the highly sensitive girls were better at internalizing and applying the intervention strategies due to their deeper processing style, leading to better outcomes (Pluess & Boniwell, 2015). Furthermore, two fMRI studies found evidence for increased responsivity to emotions in high SPS individuals. The first one (Study 2, Jagiellowicz, 2012) exposed participants to an array of pictures of neutral, positive or negative valence and found an association of SPS with brain activity in limbic and reward-related areas when watching positive, but not negative (vs. neutral) stimuli. These results were supported by a behavioral study (Study 1, Jagiellowicz, 2012) wherein individuals with SPS that were subjected to positive parenting during their childhood reported higher arousal ratings in response to positive pictures compared to neutral pictures (which was not the case for the control group). No such interaction was found for negative parenting and arousal for negative pictures.

The second study (Acevedo et al., 2014) used neutral, happy and sad facial expression of participants' romantic partners and of strangers as stimuli. SPS was found to be related to higher activation in brain areas associated with awareness, empathy, motor preparation, and integration of sensory information (Acevedo et al., 2014). This activation was stronger for the sad and even stronger for the happy facial expressions compared to the neutral condition, especially when watching facial expressions of partners. At last, individuals with SPS (approximately the highest 25% of scorers on SPS) that participated in the most recent study (Jagiellowicz, Aron, & Aron, 2016) rated the emotional valence of negative and especially positive pictures on a 9-point Likert scale higher than participants low in SPS (approximately the lowest quartile of the sample). In addition to that, high SPS individuals that experienced positive parenting during childhood reported significantly higher arousal in response to positive stimuli (compared to low SPS individuals), while negative parenting yielded no such interaction effect in this study.

Shortcomings in SPS Research and Aim of the Current Study

Taken together, these results indicate that SPS may indeed be related to a general higher reactivity, in particular with regard to emotions. Even though research in recent years has experienced a slight shift away from purely subjective measures, studies applying perceptual, physiological, experimental or behavioral methods to study SPS are still rare. Therefore, several authors (e.g., Booth, Standage, & Fox, 2015; Smolewska et al., 2006) have remarked that future studies examining SPS should include measures that are more objective than the often-used self-reports. Besides the questionnaires often used to measure psychological variables associated with SPS, the trait itself is exclusively screened for by means of the HSP-Scale. This self-report questionnaire is not without its concern, as several authors have questioned its unidimensionality by identifying at least a second factor that corresponds strongly to the trait of negative affect or neuroticism (Booth et al., 2015; Evans & Rothbart, 2008; Smolewska et al., 2006). Research using additional, objective measures that might show specific patterns hinting at a higher processing sensitivity is needed to advance our understanding of SPS and eventually confirm or disconfirm the results obtained from self-reports.

The fMRI research mentioned above (Acevedo et al., 2014; Aron et al., 2010; Jagiellowicz, 2012; Jagiellowicz et al., 2011) represents a step in the right direction and provides important insights into emotional and elaborative information-processing in SPS. The way these experiments were executed however does not allow for an inspection of a possible lower threshold to low-intensity stimulation in SPS due to the relatively long presentation times of stimuli. At last, and most importantly, fMRI research alone cannot explain the underlying mechanisms and patterns that might be responsible for the deeper processing style or the higher reactivity associated with SPS. Clearly, there is need for implementing new experimental paradigms into the field of SPS research that allows for the investigation of these mechanisms by analyzing processing differences at both automatic and elaborative stages of information-processing, and for a variety of stimuli of a different emotional valence.

For this purpose, attentional bias research may be an appropriate candidate. Jagiellowicz et al. (2016) already theorized that their susceptibility to being influenced by the environment and their higher reactivity may potentially be due to individuals with SPS' attentional bias towards both positive and negative experiences and stimuli. The reason why such attentional biases may underlie the enhanced processing and stronger emotional reactions to environmental stimuli in SPS is that orienting, or aligning one's attention with an external stimulus (Posner, Snyder, & Davidson, 1980), plays a crucial role in deciding which information from the environment an individual will perceive, thereby shaping and influencing the individual's subsequent reactions (Ellenbogen, Schwartzman, Stewart, & Walker, 2002). Consistent with this proposition, attentional capture by emotional cues and the dwelling of attention on emotional material have been shown to be associated with heightened emotionality as a consequence of the emotional valence of the cues (e.g., Joormann & Quinn, 2014; Koster, De Raedt, Leyman, & De Lissnyder, 2010; Mathews & MacLeod, 2002). Furthermore, there is evidence that attentional biases can influence emotionality, or at least emotional vulnerability to subsequent stressors (for a review, see Van Bockstaele et al., 2014). This provides evidence that differences in attentional processes are not merely a marker of emotionality, but can also be causally involved in its onset (Browning, Holmes, Charles, Cowen, & Harmer, 2012). As these possible mechanisms have never been tested before with respect to SPS, the aim of the current study was to explore if HSPs and high SPS individuals indeed differ in the manner how they attend to incoming visual stimuli.

Paradigm and Research Questions

To investigate these potential differences in attentional processing in the current study, we will use the emotional modification (Fox, Russo, Bowles, & Dutton, 2001) of the Posner exogenous cueing task (Posner, 1980). This paradigm has the ability to isolate the different attentional components (Kircanski, Joormann, & Gotlib, 2015), as attentional processes are not unitary, but supposedly consist of three different subcomponents: Before attention can "shift" or move in space and "engage" at a new location for facilitated processing, it first has to "disengage" or withdraw from its earlier location (Posner & Cohen, 1984; Posner, Inhoff, Friedrich, & Cohen, 1987).

In the emotional exogenous cueing task, participants are presented with a cue before having to respond to the left-right location of a target stimulus (e.g., a dot). Cue and target can either appear on the same side (valid trials) or on opposite sides (invalid trials) of the screen. As attention is automatically attracted by the cue at early processing stages, respondents are usually faster in responding to valid than to invalid targets when the temporal interval between cue and target (stimulus onset asynchrony, or SOA) is short (Posner, 1980). This cue validity effect normally reverses at longer SOAs (> 300 ms) because attention to a previously attended stimulus is suppressed in order to attend to new locations (also called the inhibition of return effect or IOR, Posner

& Cohen, 1984). The manipulation of the emotional valence of the cues (positive, neutral and negative) hereby makes it possible to examine which type of information affects attention the most: If a stimulus of a certain valence is associated with facilitation of early processing, one would expect stronger cue validity effects following this cue at the short SOA. A diminished IOR for cues at the longer SOA would indicate maintained attention to the stimuli at later processing stages (Fox et al., 2001). The exact cognitive operations involved in the facilitation and maintenance of attention by emotional content can then be examined by comparing reaction times for valid and invalid emotional with valid and invalid neutral trials. More specifically, engagement signals faster orienting towards emotional material and involves faster responses to valid emotional compared to valid neutral trials. Due to the attentional holding exerted by the emotional stimulus, difficulties in attentional disengagement from emotional stimuli will manifest themselves as slowed responding on invalid emotional trials compared to invalid neutral trials (Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004; Koster, Crombez, Verschuere, Damme, & Wiersema, 2006; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005).

In that way, the method presented above lends itself perfectly to study some shortcomings of SPS research discussed in the beginning. To be more precise, the emotional variant of the exogenous cueing task makes it possible to examine to which kind of stimulus an individual is drawn or keeps attending to and if this happens automatically or due to a more elaborate processing. On the one hand, this could clarify if SPS is more related to and driven by a higher awareness and lower threshold to stimulation from the environment, by a deeper processing thereof, or both. In case of a lower threshold to stimulation, this would normally manifest itself in stronger cue validity effects and enhanced engagement scores at short SOAs compared to controls. If deeper elaboration plays a prominent role, one would usually observe decreased IORs delayed disengagement scores at long SOAs (vs. controls). Presenting highly sensitive individuals with neutral and both positive and negative emotional stimulus material could furthermore provide additional evidence for either the diathesis-stress or the differential susceptibility framework: If highly sensitive individuals are only vulnerable to negative events and stimulation, one would expect stronger attentional biases in comparison to controls only for negative stimuli. If the differential susceptibility hypothesis instead holds true, one might expect enhanced attentional biases of highly sensitive participants for the negative as well as the positive information compared to controls.

To further explore these ideas, we submitted individuals with SPS and controls to a modified exogenous cueing task previously implemented by Kircanski et al. (2015). As stimuli, emotional faces were used due to their higher ecological validity (Bradley, Mogg, Millar, et al., 1997). The emotional valence of the stimuli was varied (neutral, sad, angry, and happy) to study emotion-specific attentional effects. To examine early and late processing, stimuli were presented for a duration of 200ms or 1000ms. Besides that, participants had to fill in a set of surveys to obtain a more extensive picture of possible associations of SPS with a variety of different personality and psychological health variables and to eventually control for possible confounds. This is especially important for the traits of negative affect and introversion that are often positively related to SPS and that should always be controlled (Acevedo et al., 2014; E. N. Aron et al., 2012; Jagiellowicz, 2012). The rationale for including the various questionnaires as well as the variables that are measured by the self-reports are accounted for in the method section.

Summarized, the following research questions were asked:

(1) Is SPS characterized by differential information-processing, and if so, is this due to a lower threshold for information and/or a deeper processing style?

(2) Is the attentional bias in SPS specific for negative material (angry and/or sad stimuli) or is there evidence of a general bias for emotional (angry, sad, and happy) and even neutral stimuli?

Method and Materials

Participants

Participants were a Dutch-speaking convenience sample from the Flemish region in Belgium. They had to be at least 18 and less than 36 years old and were excluded from the study if they were taking psychiatric medication or beta blockers or had a psychiatric diagnosis. The high SPS group (n = 15) was recruited through an advertisement in "De Cocon", a magazine that is launched every two months by the Flemish Association for Highly Sensitive Persons (HSP Vlaanderen). The control group (n = 15) was recruited through social networking sites. The total sample consisted of 21 females and nine males with ages ranging from 19 to 35 years. The percentage of working people (53.3%) and students (46.7%) was about the same. The majority of participants had a very high educational background (73.3% university or university of applied sciences students or absolvents). Demographic characteristics of the two groups are displayed in Table 1.

Table 1
Demographic characteristics of the high SPS and control groups and results of between groups comparisons

	High SPS	Controls	Between Groups tests	
	Number or M (*SD*)	Number or *M* (*SD*)	test value	*p*-value
Gender				1
Male	4	5		
Female	11	10		
Work Situation			4.82	.028
Working	11	5		
Not Working	4	10		
Education Level				.717
Lower Secondary	1	0		
Higher Secondary	3	4		
Higher Non-University	7	6		
University	4	5		
Age	28.07 (5.27)	24.67 (3.50)	2.08	.048
HSPS score	153.87 (15.73)	93.47 (15.35)	10.65	< .001

Questionnaires

The Highly Sensitive Person Scale (HSPS, Aron & Aron, 1997) was administered in order to assign participants to the high SPS or control group. Participants completed a Dutch translation of the HSPS which was also translated backwards to control for eventual translation errors. This scale measures the degree to which participants have sensory processing sensitivity (SPS). Respondents are asked to rate their agreement with 27 items that reflect their sensitivity to different internal and external states or events on a 7-point Likert scale (1 = Not at All and 7 = Extremely). The HSPS has been shown to possess good discriminant and convergent validity as well as high internal validity, with Cronbach's alphas of .85 or higher (Aron & Aron, 1997; Aron et al., 2005). Alpha in the present study was .97.

The Adult Temperament Questionnaire (ATQ; Rothbart, Ahadi, & Evans, 2000) was taken in order to account for the closely to SPS related traits of neuroticism and extraversion and for attentional control (which can moderate attentional biases; e.g., Derryberry & Reed, 2002). Besides that, the ATQ includes a scale (Orienting Sensitivity) that might be able to measure SPS and confirm the results gained from the HSPS. Participants had to complete the official Dutch translation of the ATQ short form (Hartman, Majdandžić, & Rothbart, 2001). The questionnaire consists of 77 items, measuring four different temperamental traits that each comprise three or four subscales. Negative Affect is an indicator of neuroticism that includes the subscales fear, sadness, discomfort, and frustration. Effortful Control measures the capacity to voluntarily shift and focus one's attention, to suppress a behavior, and to perform an action despite a strong avoidance tendency. Extraversion/Surgency is a measure of positive affect, sociability, and gaining pleasure from intense stimulation. Orienting Sensitivity measures to what extent individuals are aware of low intensity emotional and neutral stimuli and their capacity to make spontaneous, nonstandard associations with the environment. Participants had to rate how well the different items described themselves on a 7-point Likert scale (1 = Totally not applicable and 7 = Totally applicable). Additionally, the response option 'Never been in that situation' was given. The validity of the questionnaire has been demonstrated through factor analysis and correlations with the Big Five scales (Rothbart et al., 2000).

Participants had to complete the Four-Dimensional Symptom Questionnaire (4DSQ; Terluin, 1996) to investigate associations of SPS with negative mental and physical symptoms that have been demonstrated by earlier studies (e.g., Benham, 2006; Liss et al., 2008, 2005). This questionnaire consists of 50 items and measures the severity of four different dimensions of psychological complaints. The Distress scale is an indicator of general, nonspecific psychosocial symptoms. The Depression and Anxiety scales are associated with symptoms of clinical depression and anxiety disorders, respectively. The Somatization scale measures bodily reactions and complaints in the face of stressors. Participants completed the original Dutch version of the scale. They reported how often they experienced the different symptoms during the past seven days on a 5-point Likert scale (1 = never, 5 = very often or constant). Prior research has demonstrated the good validity and reliability of the questionnaire (Terluin et al., 2006).

The Rejection Sensitivity Questionnaire (RSQ, Downey & Feldman, 1996) was administered to investigate the sensibility of high SPS individuals to potential socially threatening events, which is thought to be especially present in temperamentally susceptible individuals when they have experienced rejection during childhood (Meyer et al., 2005). It might therefore be an indicator of the interaction of SPS with a negative environment. A heightened rejection sensitivity has also been associated with the avoidance of angry faces (Berenson et al., 2009) and could therefore exert a confounding influence on the exogenous cueing task. Participants responded to a Dutch translation of the 18-item version of the RSQ. Each item of the scale describes a different situation that could result in interpersonal rejection. For each situation, respondents then had to give two responses on 6-point Likert scales. One response measured their rejection anxiety (1 = very unconcerned, 6 = very concerned), the other their expectancy of rejection (1 = very likely, 6 = very unlikely). Rejection expectancy was scored inversely and multiplied with the score on rejection anxiety and then averaged across the items to compute total rejection scores (ranging from 1 to 36, with higher scores indicating greater rejection sensitivity). The RSQ has shown good internal consistency and reliability (Downey & Feldman, 1996).

The Utrecht Burnout Scale (UBOS-A, Schaufeli & Dierendonck, 2000) was taken in order to assess the association of SPS with psychological health on the work floor, which has only been investigated one time before to date (Evers et al., 2008). This scale is the Dutch version of the Maslach Burnout Inventory – General Survey (MBI-GS, Schaufeli, Leiter, Maslach, & Jackson, 1996). It contains 15 items and measures a person's degree of burnout on three different subscales (Emotional Exhaustion, Cynicism, and Competence). Respondents rated how often they have burnout symptoms on a 7-point Likert scale (0 = Never, 6 = Always). The UBOS-A has convergent and discriminant validity and high reliability (Schaufeli & Dierendonck, 2000).

Reaction Time Experiment

For the Posner exogenous cueing task, a set of 16 faces (eight male, eight female) of different ethnicities was chosen from the valid and reliable NimStim set of facial expressions (Tottenham et al., 2009). Each face expressed four different emotional valences (neutral, happy, sad, and angry). The task was presented using E-prime software (Schneider, Eschman, & Zuccolotto, 2001) on a 14-inch Dell laptop with an AZERTY keyboard layout.

The Posner cued attention task started with 20 practice trials, followed by 384 test trials. These were presented in two blocks of 192 trials that were separated by a 30 second break. One block consisted of face cues presented for 200ms, the other contained face cues presented for 1000 ms. Each block contained an equal amount of the 16 faces chosen as stimuli (each face was presented 12 times per block) with an equal amount of the four face valences (each valence was presented 48 times per block). Block order (200ms first vs. 1000ms first) was counterbalanced across participants in each group. Participants were seated 50cm in front of the computer screen and instructed to keep focusing on the fixation cross and to respond as fast and accurate as possible.

Each trial began with the appearance of a fixation cross in the center of the screen, framed by two white squares (12.4 cm x 8.7 cm, 3.1 cm apart) to its left and right. After 500ms, a face cue appeared inside one of the frames for a duration of either 200ms or 1000ms, depending on the current block. The two frames remained for an additional 50ms after the disappearance of the face cue. After that the target (a white circle) appeared on either the left or the right side. Half of the trials were valid (cue left, target left or cue right, target right), the other 50% were invalid (cue left, target right or cue right, target left). This was randomized within each block. Participants then had to respond to the location of the target by either pressing the W button with their left or the N button with their right index finger on the AZERTY keyboard. After each response, the screen remained blank for 100 ms before the onset of the next trial. The design of the experiment is illustrated in Figure 1.

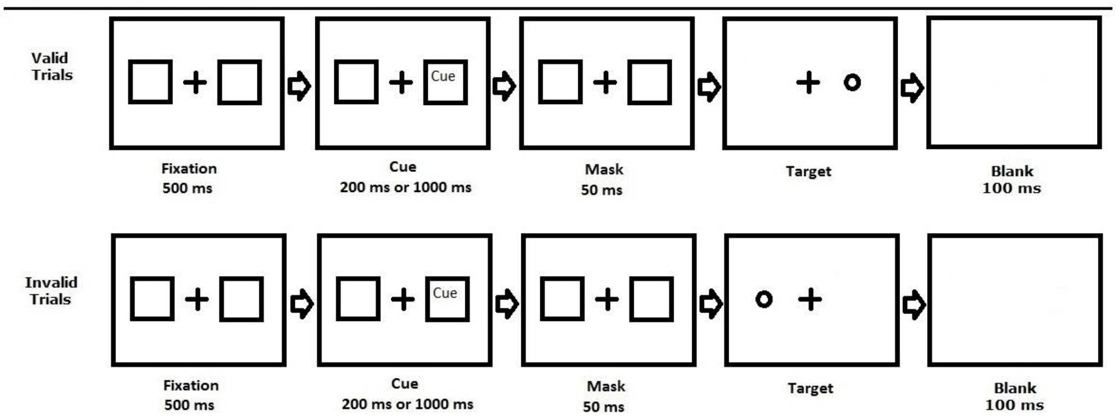

Figure 1. Screen presentation of valid and invalid trials.

Procedure

Participants who responded to the advertisement were given a link to fill in an online survey containing the questionnaires mentioned above. They were scheduled to complete the reaction time experiment one week later. They were not allowed to consume alcohol or caffeine for 24 hours prior to the onset of the experiment. The experimental sessions were either conducted at the Vrije Universiteit Brussel lab or at the participants' home in a quiet environment.

Results

Demographic Group Differences

The high SPS group had significantly higher scores on SPS than the control group. SPS scores of the experimental group ranged from 126 to 182. SPS scores of the control group ranged from 58 to 118. This is consistent with prior research that handled a cutoff score of 124 to determine group assignment (Liss et al., 2005). Fisher's exact tests (FET) revealed no group differences in gender, or education level. However, groups differed in work situation and age. The control group was younger on average and consisted of more students and other non-working individuals. The characteristics of the two groups and the outcomes of the between groups tests can be found in Table 1.

Correlational Analyses

Correlations between the HSPS scores and the ATQ, 4DSQ, RSQ, and UBOS-A scales were computed. As the 4DSQ scales and the RSQ scale were not normally distributed, Spearman correlations were used for these variables. For the relationship between HSPS and UBOS-A, only working participants (N = 16) were included as the questionnaire is meant for implementation in a work context. As can be seen in Table 2, HSPS had significant medium to high positive correlations with all the four 4DSQ scales, the ATQ Negative Affect and Orienting Sensitivity scales, the RSQ and the Emotional Exhaustion component of the UBOS and a significant highly negative correlation with ATQ Extraversion/Surgency. Correlations with the other variables did not reach significance.

As the two groups differed in age and work situation, a second correlational analysis controlling for these variables by computing partial correlations was carried out. The results remained largely the same. However, the relationship of the HSPS with the 4DSQ Depression scale and the RSQ just fell short of reaching significance this time, $p = .11$, and $p = .057$ respectively.

Finally, prior research has pointed out that SPS research should ideally control for measures of negative affect and extraversion (Aron et al., 2005; Aron, Aron, & Jagiellowicz, 2012). Therefore, a second partial correlations analysis controlling for Negative Affect and Extraversion/Surgency besides age and work situation was conducted. The only correlation that remained significant was with ATQ Orienting Sensitivity, $r(28) = .63$, $p < .001$.

Table 2

*Pearson correlation coefficients (r) and significance levels (p) between the High Sensitive Person Scale and the various Questionnaire Scales (significant correlations are flagged with *p < .05, **p < .01, and ***p < .001)*

Scales	*r*	*P*
4DSQ		
Distress	.61	< .001***
Depression	.44	.014*
Anxiety	.51	.004**
Somatization	.61	< .001***
ATQ		
Negative Affect	.82	< .001***
Effortful Control	-.077	.68
Orienting Sensitivity	.66	< .001***
Extraversion/Surgency	-.60	< .001***
RSQ	.49	.006**
UBOS		
Emotional Exhaustion	.53	.034*
Cynicism	.39	.14
Competence	-.16	.57

Reaction Time Analysis

Design and preparation of analyses. Only trials with a correct response and with a reaction time (RT) higher than 150 ms and lower than 1000 ms were included in the analysis. As a result of this, 97.7% of the total data remained to compute mean RTs as a function of cue valence, cue duration and cue validity (see Table 3). The two groups did not differ in the amount of errors they made, $t(28) = -1.01$, $p = .32$. To attain statistical normality, raw data was subjected to a log10 transformation before conducting the computations and analyses. To attain better clarity and interpretability, untransformed scores were used for Table 3 and 4 and Figure 2.

Table 3

Mean Raw Reaction Times (RTs) and Standard Deviations (SDs) as a Function of Group, Cue Valence, Cue Validity, and Cue Duration

	Raw RTs 200 ms duration		Raw RTs 1000 ms duration	
Variables	**High SPS** ***M (SD)***	**Control** ***M (SD)***	**High SPS** ***M (SD)***	**Control** ***M (SD)***
Happy				
Valid	385 (17.5)	324 (11.9)	373 (18.6)	317 (13.7)
Invalid	376 (16.9)	304 (8.8)	372 (16.2)	307 (8.7)
Angry				
Valid	400 (19.1)	319 (12.6)	376 (17.6)	315 (11.6)
Invalid	380 (17.7)	298 (8.7)	372 (21.7)	313 (10.3)
Sad				
Valid	393 (18.0)	320 (12.6)	384 (18.2)	312 (12.5)
Invalid	377 (18.5)	303 (10.7)	377 (17.1)	317 (9.9)
Neutral				
Valid	388 (16.0)	320 (12.1)	389 (22.2)	310 (11.3)
Invalid	375 (16.3)	297 (9.5)	366 (15.1)	315 (8.5)

For the reaction time (RT) analyses, the procedure applied by Koster, De Raedt, Goeleven, Franck, and Crombez (2005) was closely followed. RTs were entered in an omnibus mixed-design analysis of covariance (ANCOVA), with group as a between subjects factor and cue valence, cue validity and cue duration as within subjects factors. Age had several significant associations with RTs and has been shown to influence attention, since older individuals reliably possess a positivity bias (for a review, see Reed, Chan, & Mikels, 2014). In order to directly account for this possibility and to rule out the influence of the significantly higher age of the high SPS group, analyses deviated from the standard procedure and included age as a covariate from the beginning. Compared to analyses that were conducted without the covariate, most effects pointed in the same direction, but generally tended to be a bit stronger (which lead to the significance of some otherwise only marginally significant interaction effects[1]). If there was a relevant four-way interaction for the omnibus ANCOVA, it was further analyzed by investigating effects separately for the two cue durations (carrying out two separate ANCOVAs for the 200 ms and 1000 ms duration, with group as between and cue valence and cue validity as within subjects factors). If the respective Group x Cue Valence x Cue Validity interaction then reached significance, it was further analyzed by comparing cue validity, engagement and disengagement between and within the two groups using univariate ANCOVAs (with age as covariate) and paired-samples t tests, respectively.

Cue validity was computed as a function of cue duration (200ms, 1000ms) and cue valence (happy, angry, sad, neutral) using the formula:

Cue Validity Effect (CV) = RT invalid cue — RT valid cue. Positive scores show the usual cue validity effect, while negative scores on this index point to an inhibition of return (IOR) effect. At longer stimulus presentation times an IOR effect usually occurs; the normal cue validity effect generally arises at shorter stimulus durations.

The attentional indices of engagement and disengagement were computed as a function of cue duration (200 ms, 1000 ms) and cue valence (happy, angry, sad) applying the following formulas:

Engagement = RT valid neutral cue – RT valid valenced cue. Positive scores on this index suggest heightened attentional engagement with the emotional cue, while negative scores suggest reduced engagement.

Disengagement = RT invalid valenced cue – RT invalid neutral cue. Negative scores on this index suggest faster disengagement of attention from the emotional cue and positive scores indicate slower disengagement. Untransformed mean CVs and attentional indices can be found in Table 4.

At last, it was tested if an index score differed from zero using one-sample t tests. As Koster et al. (2005) have pointed out, an attentional index score (e.g., engagement or disengagement) could differ significantly between and within groups and still be very close to zero. If engagement scores of the one group for example were in the low negative range and the other group had low positive scores, the difference between groups could still be marked as significant. In this case, this difference would not necessarily mean much as both scores are very close to zero, and a score of zero indicates no attentional bias at all.

Outcomes of analyses.

Outcomes of the omnibus ANCOVA. Results of the initial 2 (group: SPS, control) x 4 (cue valence: happy, angry, sad, neutral) x 2 (cue duration: 200 ms, 1000 ms) x 2 (cue validity: valid, invalid) mixed-design omnibus ANCOVA (with age as covariate) revealed a significant main effect of cue valence, $F(3, 81) = 2.95$, $p = .038$, $\eta_p^2 = .098$. Participants in general responded fastest after the presentation of happy compared to neutral, angry and sad faces. The significant main effect found for group, $F(1,27) = 10.1$, $p = .004$, $\eta_p^2 = .27$, can be explained by the slower overall RTs of the high SPS group vs. controls across all conditions .

Table 4

Mean Engagement, Disengagement, and Cue Validity scores and Standard Deviations as a Function of Group, Cue Valence, and Cue Duration

	CV		Engagement		Disengagement	
Variables	High SPS *M* (*SD*)	Control *M* (*SD*)	High SPS *M* (*SD*)	Control *M* (*SD*)	High SPS *M* (*SD*)	Control *M* (*SD*)
Happy						
200ms	-8.81 (26.55)	-19.39 (29.48)	2.60 (27.60)	-3.57 (23.90)	1.65 (20.60)	7.77 (18.01)
1000ms	-0.63 (26.30)	-10.07 (37.28)	16.44 (24.16)	-7.19 (30.32)	5.87 (18.83)	-7.22 (17.91)
Angry						
200ms	-20.43 (15.14)	-20.97 (22.86)	-12.27 (21.63)	1.16 (14.27)	4.90 (22.50)	1.46 (14.51)
1000ms	-4.51 (38.34)	-2.07 (22.36)	13.09 (34.46)	-5.33 (18.19)	5.33 (37.36)	-1.08 (18.59)
Sad						
200ms	-16.08 (22.96)	-17.23 (28.94)	-5.69 (20.52)	-0.24 (14.22)	2.67 (20.72)	6.60 (16.95)
1000ms	-6.51 (23.74)	4.80 (21.06)	5.47 (30.25)	-1.75 (18.05)	10.96 (21.67)	2.21 (15.24)
Neutral						
200ms	-13.06 (19.52)	-23.56 (23.98)				
1000ms	-22.94 (33.45)	4.34 (21.29)				

Most importantly, the relevant four-way Group x Cue Valence x Cue Duration x Cue Validity interaction effect reached significance, $F(3, 81) = 3.12$, $p = .030$, $\eta_p^2 = .10$. The three-way interactions of Group x Cue Valence x Cue Validity and the two-way interaction of Cue Duration x Cue Validity were significant as well, $F(3, 81) = 3.20$, $p = .028$, $\eta_p^2 = .11$, and $F(1, 27) = 10.12$, $p = .004$, $\eta_p^2 = .27$. The interaction of Cue Duration x Cue Validity specifically points to the IOR effect (Koster et al., 2005). IOR in the current study was stronger for the 200 ms cue duration than for the 1000 ms cue duration. Both interaction effects can be subsumed under the four-way interation described above. Before further analyzing this four-way interaction by conducting two separate 2 (group: SPS, control) x 4 (cue valence: happy, angry, sad, neutral) x 2 (cue validity: valid, invalid) ANCOVAs for the two cue durations (see below), another 2 x 2x 4 x 2 omnibus ANCOVA that included the ATQ measures of negative affect and extraversion as covariates besides age was conducted. The analysis revealed almost significant main effects of cue valence and cue validity, $F(3, 75) = 2.73$, $p = .05$, and $F(1, 25) = 3.33$, $p = .08$ respectively, and a significant interaction between cue duration and cue validity, $F(1, 25) = 6.74$, $p = .016$. The cue duration x cue valence x cue validity interaction had a tendency towards significance, $F(3, 75) = 2.12$, $p = .11$. No other effects were significant (all $Fs < 2$).

Outcomes for the ANCOVA at 200 ms. For the 2 (group: SPS, control) x 4 (cue valence: happy, angry, sad, neutral) x 2 (cue validity: valid, invalid) ANCOVA at the 200 ms cue duration (with age as covariate), the only effect that showed at least a significant trend was the Group x Cue Valence interaction, $F(3,81) = 1.93$, $p = .13$, $\eta_p^2 = .067$. Across the cue valences, the high SPS group generally responded slower than the controls. There were other significant effects that pointed to relevant differences between the SPS and control group in emotional processing at the earlier stage of attention (all $Fs \leq 1.5$).

Outcomes for the ANCOVA at 1000 ms. For the 1000 ms duration, the 2 (group: SPS, control) x 4 (cue valence: happy, angry, sad, neutral) x 2 (cue validity: valid, invalid) ANCOVA (with age as covariate) revealed a significant main effect for cue valence, $F(3,81) = 3.85$, $p =.013$, $\eta_p^2 = .13$, and cue validity, $F(1,27) = 13.5$, $p = .001$, $\eta_p^2 = .33$. Participants reacted faster after seeing happy facial cues compared to angry, neutral, and sad faces. RTs across all participants were also generally faster on invalid vs. valid trials. The two-way Cue Valence x Cue Validity interaction reached marginal significance, $F(3,81) = 2.68$, $p = .053$, $\eta_p^2 = .09$. The decisive three-way Group x Cue Valence x Cue Validity effect was significant, $F(3,81) = 4.84$, $p = .004$, $\eta_p^2 = .15$, justifying further analysis of underlying simple effects. The most important simple CV and attentional component effects can be seen in Figure 2.

Paired-samples t tests showed that in the high SPS group, a significantly lower CV effect was found for neutral cues compared to happy cues, $t(14) = -3.09$, $p = .008$, $\eta_p^2 = .40$. CV for neutral cues was also marginally lower compared to sad cues, $t(14) = -2.10$, $p = .055$, $\eta_p^2 = .24$. No differences between neutral and valenced cues were found in the control group, all $ts < 1.4$. Comparisons between groups (applying univariate ANCOVAs with age as a covariate) revealed that the CV of the control group was significantly lower for happy faces and marginally higher for neutral faces, $F(1,27) = 7.27$, $p = .012$, $\eta_p^2 = .21$, and $F(1,27) = 3.12$, $p = .089$, $\eta_p^2 = .10$, respectively. However, the only CV of both groups that differed significantly from zero was the one of the high SPS group for neutral cues, $t(14) = -2.52$, $p = .025$. Taken together, the analysis of CVs thus indicates that only the high SPS group had a significantly negative CV (signaling an enhanced IOR) for neutral cues, which was absent for the valenced cues.

Regarding attentional components, the high SPS group had a significantly higher engagement for happy compared to sad cues, $t(14) = 2.24$, $p = .042$, $\eta_p^2 = .26$. No differences in attentional engagement for the various cue valences were observed in the control group, all $ts < 1.0$. Between groups, engagement of the high SPS group for happy faces was significantly stronger compared to controls, $F(1,27) = 5.94$, $p = .022$, $\eta_p^2 = .18$. The engagement score of the high SPS group for the happy facial cues was also significantly higher than zero, $t(14) = 2.66$, $p = .019$, while that of the control group was not, $t(14) = -.86$, $p = .41$.

At last, disengagement scores were examined. The paired-samples t-tests only revealed that the control group almost showed significantly faster disengagement from happy compared to sad faces, $t(14) = -1.84$, $p = .087$, $\eta_p^2 = .20$ (all other $ts < 1.0$). The disengagement from happy faces of controls was significantly faster when comparing it to the high SPS group, $F(1,27) = 6.29$, $p = .018$, $\eta_p^2 = .19$, but did not differ from zero, $t(14) = -1.57$, $p = .14$. No other effects between groups reached or approached significance, $ts < 1.3$.

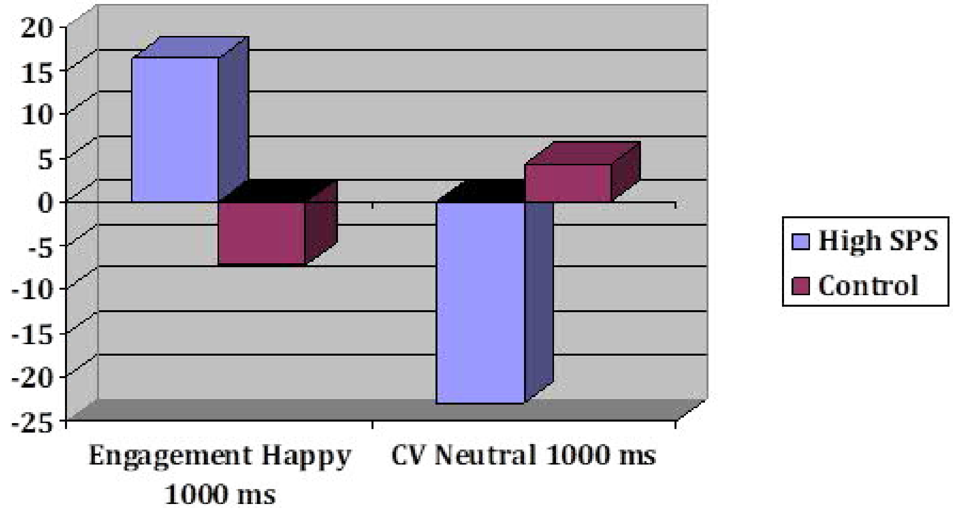

Figure 2. Statistically significant engagement and CV effects.

Discussion

Correlational Findings

Previous research has investigated specific characteristics of SPS in relation to information-processing but has not succeeded in examining potential underlying mechanisms that might be responsible for individuals with SPS' different processing style and susceptibility to environmental stimuli. The current study was one of the first that focused on this issue by analyzing the relation of SPS to attentional bias while also investigating various personality and psychological variables that have been shown to be associated with SPS.

At first sight, the correlational results of the current study seemed to be in concordance with above mentioned research that situates SPS within a diathesis-stress framework, as the trait was indeed positively associated with a variety of negative psychological outcome variables. These associations, after controlling for differences in age and work situation, were significant for anxiety, somatization, and general distress, supporting earlier findings that found evidence for such relationships (Ahadi & Basharpoor, 2010; Benham, 2006; Liss et al., 2005). The findings by Evers et al. (2008) found in a work context were only partially supported: While the significant correlation of SPS with the Emotional Exhaustion subscale of the UBOS-A found in the current sample also points to a vulnerability of high SPS individuals to work stress, no such relationships were found for the Cynicism and Competence subscales, which indicate detachment from and a feeling of efficacy at work (Taris, Houtman, & Schaufeli, 2013). Evers et al. (2008) had theorized that the overstimulation that individuals high in SPS often experience would translate itself into emotional detachment from work and a lower sense of self-efficacy and found support for it within their data. Based on the current results, it seems that this may not always be the case and that there might be ways for individuals high in SPS to preserve their sense of competence and attachment to work. At last, the correlation coefficients for depression and rejection sensitivity, while not quite reaching significance anymore, clearly point to a positive association with SPS. In summary and based on the self-reports, the higher sensitivity of individuals with SPS to stressors and potential negative feedback from their environment apparently has an adverse effect on their subjective experience of well-being.

Yet, it should be mentioned that all these associations failed to reach any significance once we controlled for the usual confounders relevant to SPS research, extraversion and negative affect, as recommended by Aron et al. (2012). This is in contrast with diathesis-stress accounts that found an effect of SPS on adverse psychological variables above and beyond confounds (Evers et al., 2008). Based on the current results, the adverse health outcomes observed initially might be better explained by these two temperamental differences and not necessarily by a difference in SPS. However, it has to be remarked that the correlation of SPS with negative affect was unusually high (r =.82 in the current study, vs. coefficients that are typically in the .40 to .60 range; Ahadi & Basharpoor, 2010; E. N. Aron & Aron, 1997; E. N. Aron et al., 2005), which is likely to lead to null findings once controlled for. This unusually high association might have been caused by a response bias and is discussed below in more detail.

Interestingly, the only correlation of the HSPS that remained relevant after screening out extraversion and negative affect was with the ATQ Orienting Sensitivity subscale. This is not surprising as Orienting Sensitivity is defined "as automatic attention to both external sensory events and internal events" (Evans & Rothbart, 2008, p. 110) and is therefore conceptually very similar to SPS. The persistence of the correlation between the two scales after controlling for negative affect further supports the argument of Evans and Rothbart (2008) that the HSPS actually measures two orthogonal constructs, negative affectivity and orienting sensitivity. Taking this into consideration, the ATQ Orienting Sensitivity subscale might be a more accurate and pure measure of processing differences in SPS, while being immune to possible confounds as a consequence of neuroticism/negative affect. The persistence of the association between orienting sensitivity and the HSPS after controlling for confounds is an additional confirmation that the two groups really differed in SPS and not only some related variables. Future research may thus indeed profit from including the ATQ in order to explore various facets of SPS and improve the convergent validity of the construct (Aron et al., 2012).

Reaction Experiment Findings

Based on the initial positive association of SPS with negative psychological variables, one would normally expect to find that this association is also reflected on a behavioral level before controlling for confounds. Usually, participants with heightened psychological complaints relating to negative affect are associated with an attentional bias for negative information (Bar-haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007; Yiend, 2010). In the current study, it would thus seem plausible that SPS would also show attentional preferences towards negative facial stimuli and/or away from positive stimuli. While the questionnaires initially pointed to a general tendency of SPS to be associated with negative psychological outcomes, these findings could not be supported by the outcomes of the behavioral experiment. The participants with SPS showed specific patterns of attention that were exclusive to this group and that pointed to an enhanced engagement towards happy facial stimuli and avoidance of neutral faces, but only at the longer cue duration. Although confounds are usually partialed out in this kind of research (e.g. Bradley, Mogg, Falla, & Hamilton, 1998), this would not seem ideal for this study from a logical point of view, as SPS was associated with higher attentional engagement only towards the positive stimuli (and an avoidance of neutral stimuli), despite the increased neuroticism and the decreased extraversion (and the marginally increased rejection sensitivity) of the high SPS group. Both neuroticism and decreased extraversion are usually associated with enhanced attention to negative material, or at least a stronger tendency to shift attention away from positive material (Amin, Constable, & Canli, 2004; Chan, Goodwin, & Harmer, 2007; Derryberry & Reed, 1994). Partialing out these confounds would also undermine any attentional effects found in such a small sample as the current one. Furthermore, controlling for confounds is not always an appropriate research method (Spector, Zapf, Chen, & Frese, 2000) and should only be done when it is theoretically meaningful (Smith & Schwartz, 1997). However, in order to provide a comprehensive report, we have included the results with both covariates (see above).

In summary, and with respect to the research questions asked in the beginning, one can conclude from the current findings that (1) the attentional mechanism related to SPS may be situated at a later stage of information processing and that engagement may be the main attentional component, and (2) that SPS may be related to an enhanced attention to positive emotional stimuli. Although this study was only preliminary and results should be interpreted very carefully, these findings deserve a closer look and will be subjected to a critical dissemination and suggestions for improvement in the following paragraphs.

(1) First of all, the fact that SPS was only linked to attentional differences when stimulus duration was long, supports the theory and earlier research that SPS may indeed involve a deeper processing style (Aron et al., 2010; Jagiellowicz et al., 2011). Similar to depressed individuals who tend to linger on negative stimuli and are influenced in their emotionality this way, the deployment of their attention on stimulus material may be a reason for the higher reactivity of highly sensitive individuals, in this case to positive stimuli. The fact that enhanced engagement, rather than impaired disengagement, is involved in this process, is unexpected as engagement is typically ob-

served at earlier stages of attention (Fox et al., 2001). It is not clear whether this peculiarity is typical for individuals with SPS and if it will be replicated in future studies. Based on the current results however, it seems that the attention of the high SPS group was rather consistently directed at the positive stimulus (Koster et al., 2005), while the ability to shift attention away when required to do so was still intact. Another possible sign of deeper processing, although situated at the response level, is demonstrated by the main effect of group found in the omnibus ANCOVA. As can be seen in Table 3 above, highly sensitive individuals were considerably slower to respond to the targets across all conditions, which could be a consequence of taking more time to process the stimuli more thoroughly.

The failure to find any meaningful effects at the short cue duration does however not rule out the possibility that earlier, automatic processes related to higher awareness and a lower threshold may still play a role in SPS. Although stimulus presentations of 200 ms or even 250 ms are widely used to assess early attention (e.g. Fox, Russo, & Dutton, 2002; Kircanski et al., 2015; Lonigan & Vasey, 2009), the IOR effect in this study was already present at the short stimulus duration (and in fact even stronger than at the longer duration). This contrasts with common findings and theory (Posner & Cohen, 1984), and might be an indication that the cue duration has been already set too high if one wants to investigate automatic stages of information processing. Future studies should thus include even shorter stimulus durations (or even subliminal cues, for an example see Bradley, Mogg, & Lee, 1997; Koster, Verschuere, Burssens, Custers, & Crombez, 2007) to further investigate this possibility.

Another potential reason for the absence of early attentional biases might be explained by the characteristics of the experimental paradigm that we used. Even though an obvious advantage of the Posner exogenous cueing task lies in its ability to measure the different components of attention (Posner, 1980), it is not without its weaknesses: Fox et al. (2001) for example argued that effects of early engagement might be underestimated because only one cue at a time is presented. As this sudden onset of the cue automatically attracts attention, the difference between valenced cues and neutral cues is reduced, making it more difficult to find engagement effects for a specific valence at short stimulus durations (Fox et al., 2001). This does not influence engagement at longer cue durations (Koster et al., 2005), which was exactly the case here. Future research exploring early attentional bias in SPS would thus profit from also considering other experimental paradigms immune to this problem, especially more recent ones such as the central cueing paradigm

(Mathews, Fox, Yiend, & Calder, 2003) or the attentional-blink task (Raymond, Shapiro, & Arnell, 1992).

(2) The presence of an attentional bias for happy faces found in the exogenous cueing task is partially in line with the outcomes of the fMRI research by Acevedo et al. (2014). These authors found that individuals with SPS compared to controls had higher brain activation when watching both positive and negative images, thereby lending support to a general higher emotional reactivity in SPS. The finding of a seemingly preferred processing of positive stimuli in SPS cannot fully support this notion and confirm the differential susceptibility hypothesis. However, it at least seems to point away from what the diathesis-stress model would predict and seems to confirm earlier research that found a susceptibility of SPS to positive emotions (Jagiellowicz, 2012). Besides that, such a positivity bias clearly contradicts the positive associations that were found between SPS and adverse psychological outcomes like negative affect based on self-reports.

There could be some potential confounding factors that may be responsible for this peculiar and apparently counterintuitive outcome. For example, it might be possible that SPS was indeed related to the negative questionnaire measures reported above, but that a moderator variable that differs between groups changed the outcome of the reaction time experiment by exerting an influence on attentional bias. After all, long stimulus presentation times allow voluntary, top-down driven processes to come into effect which are able to modulate the direction of attention (Theeuwes, 2010). In the context of psychopathology for example, Derryberry and Reed (2002), as well as Lonigan and Vasey (2009) found that a higher level of attentional control (i.e., the ability to voluntarily shift attention away or towards a stimulus) moderated anxious individuals' attentional bias towards threatening stimuli at a longer cue duration that allows for a more conscious processing of information. If the significantly more neurotic high SPS group in the current study was originally drawn to the negative stimuli but had a higher capacity to instead direct the attention away from this material towards more pleasurable stimuli, this could explain the enhanced engagement towards the happy faces. This possibility however can be ruled out here, as SPS did not correlate with the ATQ measure of effortful control at all (see results above).

Another possible moderator variable is mood state. This variable has been consistently shown to influence cognitive biases in prior research (e.g., Bradley, Mogg, & Millar, 2000; Fox et al., 2001). Usually, this does not pose a great problem, as participants tend to make judgements and answer questionnaires in a manner that is in line with their current mood (Mayer, Gaschke, Braverman, & Evans, 1992; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). However, in the current study, participants filled in the questionnaires a few days before the experiment was executed, so it is still possible that participants' actual mood changed in the meantime and differed between groups while doing the behavioral task. A heightened positive mood of the high SPS group compared to controls while completing the Posner task could be the underlying reason for the attentional bias towards happy faces. To account for this possibility, it is highly recommended to include a measure of mood state (like the Profile of Mood States, McNair, Lorr, & Droppleman, 1992), or at least conduct the survey directly before the behavioral experiment.

A third potential confound is that the SPS participants had a general response bias towards higher scores on negative variables of the questionnaires. To begin with, the high SPS group was sampled by using an advertisement in a journal specially directed at this population and with the goal of providing information about the trait. It is thus very likely that the participants were well aware of their own SPS and that it has often been related to negative psychological variables. Such implicit theories are well-known for their ability to produce method biases in behavioral research (Podsakoff et al., 2003). Besides that, the battery of questionnaires began with the HSPS first, which consists of a lot of questions like "Do you find it unpleasant to have a lot going on at once?", "Are you made uncomfortable by loud noises?" or "Do you get rattled when you have a lot to do in a short amount of time?" As these are formulated in a rather emotionally negative manner and together form a factor strongly related to negative affect (Evans & Rothbart, 2008), this might have created a bias in participants to score higher on the following negative questionnaire measures, too, in order to preserve a consistency in their answers (also known as the consistency motif, see Podsakoff, 1986; Podsakoff et al., 2003). If this overreporting of psychological problems and complaints was indeed the case, this could explain the discrepancy between self-report and behavioral measures and why no effect for negative stimuli was found. To avert such potential response biases in future studies, participants should only be informed that the research investigates SPS or that they were selected based on their score of SPS at the moment of debriefing.

At last and most importantly, it has to be mentioned that the finding of an engagement towards positive faces found here has to be taken very cautiously, because it might actually be an artifact of the IOR and the formulas by which the attentional indices are computed (Koster et al., 2005). Since engagement is computed by subtracting the RTs of the valid valenced cues from the RTs of the valid neutral ones, a positive and significant engagement score does not necessarily imply that participants reacted and engaged particularly fast to the valenced cues. It could also have its origin in exceptionally slow RTs for the valid neutral stimuli. Indeed, the cue validity effect in the high SPS group for neutral stimuli at the long cue duration was significantly lower compared to both happy stimuli and compared to zero, signaling an enhanced IOR for neutral stimulus material. This means that SPS participants averted their attention more strongly away from valid neutral material at the longer cue duration, increasing RTs on valid neutral trials, and thereby increasing engagement effects. Besides that, the high SPS group's cue validity effect for happy faces at the long stimulus duration was not significantly higher than zero. This does not fully support the notion gained from the engagement scores that the group had an especially high attention towards the positive faces.

While all of this somewhat puts the enhanced attentional engagement of the high SPS group into perspective, one should not forget that this effect was significantly higher than zero and exclusive for happy faces, whereas being completely absent for sad and angry stimuli. Taken together, all of this does not rule out the fact that highly sensitive individuals in the current sample displayed some form of preference for the positive stimuli. However, it should be taken as a sign and warning to not jump to any premature conclusions based on this small exploratory pilot study. After all, research on SPS and attentional bias is still scarce and possesses vast room for improvement. The ability to find effects despite all the caveats and open questions discussed, shows that attentional bias research could turn out to be a promising approach to study SPS and to supplement fMRI and self-report studies. While the main goal remains to uncover early and late attentional mechanisms for emotional processing, a particularly interesting question concerns the avoidance of neutral information found in the current sample, and if future studies will be able to replicate this. At present, it is not clear what purpose lies behind avoiding such material. In classic psychopathology research, avoidance of negative information is usually seen as a strategy to regulate negative emotions and arousal (Applehans & Luecken, 2006; Joormann & Quinn, 2014). In a similar way, highly sensitive individuals could possibly divert attention away from neutral cues in order to save processing resources for more relevant (emotional) stimuli and to prevent sensory overload. This is however only speculative and should be subjected to further examination.

Further Limitations and Implications for Future Research

Besides the ideas for improvement already mentioned, this research had technical limitations as it was only a first preliminary study on potential attentional biases in high SPS individuals. In the first place, the two groups differed in work situation and age. Future research should strive to obtain more balanced groups and, in the process, would not have to fall back on procedures that have to exclude these variables as done in the present study. Participants predominantly came from a higher educational background; this combined with the small sample size of only 15 participants per group limits the generalizability of the current results. A small sample size also reduces the probability to find any significant effects (Duque & Vázquez, 2015). Furthermore, the current study did not sample its participants based on the extreme groups approach as done in prior research that found significant effects of SPS on variables such as the effectiveness of a depression intervention program (Pluess & Boniwell, 2015) or emotional arousability (Jagiellowicz, 2012; Jagiellowicz et al., 2016). This approach is able to increase the statistical power of subsequent analyses and may actually even inflate the chances of finding significant effects (Preacher, Rucker, MacCallum, & Nicewander, 2005). Although not applying such a potentially distortive procedure is an advantage of the current study, this could additionally account for the failure to find more effects and differences between the control and the high SPS group. Nevertheless, significant relevant effects have been found for longer stimulus presentations in the current study.

Another constraint of the method used in the current study lies in the fact that SPS is thought to be a fundamental biological sensitivity that interacts with environmental variables to predict different outcomes (Aron et al., 2012). Due to this interaction, it is difficult to disentangle the unique contribution to the results made by SPS from possible confounding variables that are a result of a dynamic interaction between SPS and a specific environment. Partialing out potential confounds can be a remedy against this, but is not always the optimal solution, as explained above. A possible way to rule out confounds is gaining control over potential environmental influences by experimentally manipulating them. For example, mood induction procedures used in prior research were able to bring forth changes in attentional biases (e.g., Bradley, Mogg, & Lee, 1997; Richards, French, Johnson, Naparstek, & Williams, 1992). Due to the proposed higher emotional reactivity of individuals with SPS, it may be that this manipulation would exert a stronger effect on highly sensitive individuals, in the process influencing their subsequent attentional bias stronger according to the induced mood.

The manipulation of attentional biases as done in cognitive bias modification experiments may represent another promising branch of research to further explore the construct of SPS. While manipulating cognitive bias towards positive or away from negative stimuli does not necessarily change mood in a direct way, it has been shown to cause reduced vulnerability to emotional stressors (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Tran, Siemer, & Joormann, 2011). It would be intriguing to know if high SPS individuals were more sensitive to these kinds of manipulations, thereby rendering them more or less vulnerable to subsequent environmental stressors compared to controls. As cognitive behavioral therapy is theorized to improve psycho-pathological symptoms by changing attentional biases (Beck, 1995), this may also shed more light on why Pluess & Boniwell (2015) found stronger treatment effects on high SPS participants for their therapeutic intervention.

Although the use of more naturalistic and ecologically valid facial stimuli is one of the strengths of the current study (Bradley, Mogg, Millar, et al., 1997), it might still be worthwhile to employ word stimuli instead in future research. This would allow for recall tests following the attentional task in order to assess potential memory biases in high SPS individuals. Attentional bias in depression or dysphoria, for example, is thought to deepen elaboration on negative material, thereby enhancing memory of negative words (Koster et al., 2010). As high SPS individuals have been shown to process information more deeply than control subjects (Aron et al., 2010), it would be highly interesting to examine if eventual attentional biases for word stimuli found in high SPS participants would also translate to enhanced memory of those stimuli.

Summary and Conclusion

In summary, the present study represented a first step to introduce SPS into the field of attentional biases and was successful in finding preliminary attentional differences between SPS and control groups despite a very small sample size. The mechanisms that drove these differences seemed to be a continuous deployment of attention on positively valenced stimuli and a stronger shift of attention away from neutral information in individuals with SPS. The longer cue duration associated with these attentional biases, in conjunction with general slower RTs of individuals with SPS, might be indicative of an elaborated, deeper form of processing. Still, this does not rule out the possibility that earlier, bottom-up driven mechanisms might also play a role in SPS. To better account for this, follow-up studies could implement even shorter stimulus durations or different experimental paradigms that are more sensitive to automatic processes.

The positivity bias found at a behavioral level of analysis seemed to conflict with diathesis-stress views on SPS and the negative psychological outcomes that were observed in self-reports. Due to some methodical shortcomings that will need to be improved in the future, it is not possible to fully explain these discrepancies. Even though one potential confound, namely effortful control, was definitely ruled out as an explanation for processing differences between individuals with SPS and controls, differential mood state and response biases as a consequence of the selection and study procedure might still have affected the results. Another point to consider was the potential inflation of the engagement effect by the enhanced IOR in individuals with SPS that was observed for neutral cues. This does not completely take away the meaning from the attentional engagement since it was specific only for the happy cues. Moreover, the avoidance of neutral information in individuals with SPS was an intriguing finding itself. It might be a way to prevent overstimulation and to make room in processing resources. These ideas should be further investigated.

Taken together, the current study has demonstrated that researching attentional biases shows great potential in contributing to the understanding of the functionality of SPS and opens up interesting avenues for future research. Once the effects of the current study are firmly established with larger and more balanced samples, we will be able to make clearer statements regarding the nature and time course of the attentional biases in SPS and contrast the findings with self-report measures. Besides, it could also explore new avenues such as mood induction, memory bias or attentional bias modification procedures.

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Footnotes

[1] For the initial ANOVA, the Cue Validity x Cue Valence x Group interaction, F(3, 84) = 2.33, p = .08, and the Cue Validity x Cue Valence x Cue Duration x Group interaction, F(3, 84) = 1.96, p = .13, reached a tendency towards significance (for the ANCOVA, both these effects were significant). The main effect for Cue Validity in contrast was marginally significant for the ANCOVA, but significant when carrying out the ANOVA, F(1, 28) =14.1, p = .001. The Cue Duration x Cue Validity interaction and the main effect of Group were significant in both analyses (F(1, 28) = 11.5, p = .002, and F(1, 28) = 14.6, p = .001 respectively for the ANOVA). The main effect of Cue Valence was statistically significant for the ANCOVA, but failed to reach significance for the ANOVA, F(3, 84) = .81, p = .49.