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# Sensory processing sensitivity and its association with seasonal affective disorder

Liv V. Hjordt[a,b,*], Dea S. Stenbæk[a,b]

[a] Neurobiology Research Unit, Rigshospitalet, Blegdamsvej, DK-2100 Copenhagen O, Denmark
[b] Center for Integrated Molecular Brain Imaging, the Neuroscience Centre, 9 Blegdamsvej, Rigshospitalet, DK-2100 Copenhagen O, Denmark

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ABSTRACT

It has been hypothesized that an increased sensitivity to the surroundings, can leave some individuals vulnerable to experience the environmental stress of winter more overwhelming, thus leading to a greater risk of Seasonal Affective Disorder (SAD). However, the association between trait Sensory Processing Sensitivity (SPS) and SAD is not known. We therefore aimed to investigate: 1)cross-seasonal group differences in trait SPS, in 31 individuals with SAD compared to 30 age-, gender- and education-matched healthy controls, and 2)the association between trait SPS in remitted phase (summer) and depression severity in symptomatic phase (winter) in individuals with SAD. All participants completed the Highly Sensitive Person Scale, as a measure of SPS, and the Major Depression Inventory in summer and in winter, using a longitudinal and seasonally counterbalanced design. In both remitted and symptomatic phase, individuals with SAD exhibited higher trait SPS compared to healthy controls, which for individuals with SAD was heightened during depression in winter. Notably, when averaged across season, about 25% of the individuals with SAD display high-sensitivity whereas this is only the case for 5% of the healthy controls. In addition, higher trait SPS in summer was associated with more severe SAD symptoms in winter. Our findings suggest that those with SAD are more likely to score high on SPS and that high SPS may be a vulnerability marker related to more severe SAD symptomatology.

## 1. Introduction

Seasonal Affective disorder (SAD) is a debilitating disorder, which afflicts approximately 12% of the Copenhagen population (Dam et al., 1998). It manifests as season-triggered depression, which most often develops during autumn-winter and remits the following spring-summer (Rosenthal et al., 1984). The pronounced environmental impact of seasonal changes in daylight hours in northern latitude-counties is considered an important etiology of SAD (Hébert, 2010), but female gender, youth (Magnusson and Partonen, 2010) and certain genes (Willeit et al., 2003) are also linked to risk of SAD.

We have previously shown that the transition from summer to winter is associated with changes in the personality traits Neuroticism (↑) and Extroversion (↓) in individuals with SAD, and that higher trait Neuroticism during the remitted phase in summer is linked to a greater severity of depression during the symptomatic phase in winter (Hjordt et al., 2018). Beyond typical risk traits for depression such as Neuroticism (Kotov et al., 2010; Malouff et al., 2005), it has been suggested that higher scores on trait Openness uniquely characterize individuals with SAD compared to non-seasonal depressed individuals, and norm data (Enns et al., 2006). This is hypothesized to reflect a heightened sensitivity to their surroundings, so that such individuals may experience normal mood fluctuations and the environmental stress of winter more intensely (Bagby et al., 1998; Murray et al., 2002), leading to greater risk of SAD. Interestingly, we were not able to replicate the finding of higher trait Openness in individuals with SAD when compared to matched healthy controls (Hjordt et al., 2018). Using matched healthy controls is arguably a superior design to that of comparing with norm data, however our matched healthy control group unintentionally exhibited higher scores on trait Openness compared to Danish norms. This is an “Openness bias” often observed in individuals volunteering for research (a key component of this trait refers to an open attitude towards ideas and intellectual curiosity), and in our case, it may have hampered our ability to detect group differences between individuals with SAD and healthy controls.

The notion of highly sensitive individuals has recently been proposed as an independent and genetically determined trait, reflecting increased trait Sensory Processing Sensitivity (SPS) to a variety of information (Aron et al., 2012). Although previous research has shown a moderate positive correlation between trait SPS and trait Openness

* Corresponding author.
*E-mail addresses:* Liv.hjordt@nru.dk (L.V. Hjordt), Stenbaek@nru.dk (D.S. Stenbæk).

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(Ahadi and Basharpoor, 2010; Smolewska et al., 2006; Sobocko and Zelenski, 2015), Aron and Aron (1997) suggest that trait SPS is partially distinct from this personality trait. For example, SPS does not entail intellectual curiosity or preoccupation with ideas, which may render it more suitable when using healthy controls opting for participation in research. Approximately 25% of the general population is believed to be highly sensitive and tend to display lower information thresholds, e.g., leading to better detection of subtle changes in the environment. High SPS have traditionally been interpreted from a diathesis-stress perspective, i.e. more sensitive individuals are more vulnerable to the negative effects of environmental influences, while less sensitive individuals are more resilient when experiencing the same negative adversity, and are supported by studies linking high trait SPS to negative outcomes and maladaptive behavior, including higher levels of depression, anxiety and stress (Bakker and Moulding, 2012; Liss et al., 2008). However, other perspectives have also been put forward that emphasizes how high sensitivity may be both negative (e.g., being overwhelmed by environmental stimuli) and positive (e.g., increased awareness and gratitude of the environment) in a *for-better-and-for-worse* manner, e.g. Environmental Sensitivity Theory (Pluess, 2015) or the Differential Susceptibility Theory (DST) (Belsky, 1997, 2005; Belsky et al., 2007; Belsky and Pluess, 2009). Whether individuals with SAD exhibit higher trait SPS than healthy controls, and whether this is related to the severity of the depression, is unknown.

We here, for the first time, investigated cross-seasonal group differences in trait SPS in individuals with SAD compared to age-, gender- and education-matched healthy controls, using a longitudinal and seasonally counterbalanced design. We further investigated whether trait SPS in the remitted phase is associated with the severity of depressive symptoms in the symptomatic phase amongst individuals with SAD. We hypothesize that: *(1)* Individuals with SAD exhibit higher scores in trait SPS compared to healthy controls across season, i.e., in both the remitted and the symptomatic phase, and *(2)* in individuals with SAD, higher scores in trait SPS in the remitted phase is associated with more severe depressive symptoms in the symptomatic phase.

## 2. Methods

### 2.1. Participants

We recruited healthy controls and potential individuals with SAD through Internet and newspaper advertisement, please see Hjordt et al. (2017a) for a detailed description of recruitment procedures. The exclusion criteria were age < 18 or > 45 years, past or present neurological conditions, significant somatic or psychiatric illness according to International Classification of Diseases, 10th revision (ICD-10) (WHO, 1994), other than SAD, for potential individuals with SAD, the use of recreational illegal drugs including cannabis within the last week or more than 10 times in total in lifetime (cannabis was allowed up to 50 times in total in a lifetime), any form of known retinal pathology, use of photosensitizing medications, pregnancy, night shift work, and travels to countries with a significantly different latitude six months prior to assessments. No psychotropic drugs or bright light therapy within the past year were permitted for individuals with SAD.

After initial screening, all potential participants completed a Danish version of the Seasonal Pattern Affective Questionnaire (Rosenthal et al., 1987) from which a global seasonality score (GSS) was obtained [GSS; range from 0–24]. SAD candidates were required to have a GSS ≥ 11 with a seasonality problem rating of at least moderate (Kasper et al., 1989) and healthy controls were required to have a GSS ≤ 10 with a seasonality problem rating of zero. Educational scores were rated on a scale from 1 = no vocational education to 5 = academic education > 4 years. The SAD diagnosis i.e., presented with SAD during winter (November—February) and full remission in summer (May—July) was established by trained psychiatrists, where major depression disorder was confirmed using ICD-10 diagnostic criteria and the SAD criteria suggested by (Rosenthal et al., 1984) was applied to confirm a seasonal pattern.

A total of 31 individuals diagnosed with winter-SAD and 30 age-, sex, and education-matched heathy controls with no seasonality symptoms were included in the current study. To counter the confound of seasonal effects with practice effects, the groups were counterbalanced with regard to time of first examination to; 17 individuals with SAD and 14 healthy controls who were first examined in summer and then in winter, and 14 individuals with SAD and 16 healthy controls in the reverse order. All participants completed the Highly Sensitive Person (HSP) Scale (Aron and Aron, 1997) and the Major Depression Inventory (MDI) (Bech et al., 2001) twice; once in summer and once in winter.

The study complied with the latest version of the Declaration of Helsinki, and the Capital Regions Ethics Committee approved the study (H-1-2010-085 with amendments). Written informed consent was obtained from all participants after the nature of the procedures had been fully explained. Subsamples of the study individuals has been used in previous studies by Mc Mahon et al. (2016), Jensen et al. (2016), Hjordt et al. (2017a), Hjordt et al. (2017b) and Hjordt et al. (2018).

### 2.2. Self-report measures

#### 2.2.1. Highly Sensitive Person (HSP) scale

The HSP Scale (Aron and Aron, 1997) is a validated self-report inventory intended to examine individual differences in sensitivity to a variety of internal and external factors. It comprises 27 items, which are rated on a 7-point Likert scale from 1 = strongly disagree to 7 = strongly agree. Originally, the HSP Scale was developed to measure a unidimensional trait, i.e. trait SPS, however

In addition, to a clear overarching sensitivity factor, Smolewska et al. (2006) and Lionetti et al. (2018) also found support of three separate trait SPS subcomponents; Ease of Excitation (EOE: the feeling of becoming mentally overwhelmed by external and internal demands), Low Sensory Threshold (LST: increased unpleasant arousal of sensory stimuli) and Aesthetic Sensitivity (AES: being aware of subtle aesthetics in the environment). The trait SPS total score is computed by adding up the scores from all 27 items (scores range from 27–189). EOE consists of 12 items (scores range from 12–84), LST consists of 6 items (scores range from 6–42) and AES consist of 7 items (scores range from 7–49). Internal consistency was examined with Cronbach's alpha (α). In the present study α for trait SPS were; $SAD_{summer} = 0.91$, $SAD_{winter} = 0.91$ and for Healthy $controls_{summer} = 0.85$, Healthy $controls_{winter} = 0.87$.

#### 2.2.2. Major Depression Inventory (MDI)

The MDI (Bech et al., 2001) is a self-report inventory of depressive symptoms according to DSM-IV and ICD-10 diagnostic criteria and can also be used to evaluate depression severity (Bech et al., 2015). It comprises 10 items, which are rated on a 6-point Likert scale from 0 = never to 5 = all the time based on the recollection of the last 14 days. Severity scores on the MDI ranged from 0—50. Internal consistency was examined with α, and in the present study α for MDI were; $SAD_{summer} = 0.76$, $SAD_{winter} = 0.74$ and for Healthy $controls_{summer} = 0.60$, Healthy $controls_{winter} = 0.73$

### 2.3. Statistical analyses

Demographic differences between individuals with SAD and healthy controls were examined with Mann–Whitney *U* tests while Fisher's exact test was used to examine categorical data.

To test our first hypothesis, we applied a linear mixed-effect model to evaluate group differences in SPS in summer and in winter, respectively, seasonal differences in SPS for individuals with SAD and healthy controls, respectively and differences in seasonal variation in SPS between the two groups (i.e. the interaction between group and season),

including the covariates age at baseline, sex and order of assessment. Mixed-effect models were chosen over standard linear models to account for the correlation between summer and winter assessments, using a random intercept at the participant level. Education was evaluated as covariate in the model but did not change the results and was therefore excluded from the analyses. Whenever a significant association between group and trait SPS was observed, a linear mixed-effect model including the same covariates was fitted for each of the three trait SPS subcomponents. Because we have previously shown that transition from summer to winter is associated with an increase in personality trait Neuroticism and a decrease in trait Extraversion in individuals diagnosed with SAD (Hjordt et al., 2018), we included trait Neuroticism and trait Extraversion as additional covariates in a post hoc exploratory linear mixed model analysis, evaluating group, season and group-by-season differences in trait SPS, to exclude confounding effects of these personality traits on our results. In the mixed-effect models, we used Wald tests to evaluate significance levels.

In order to test our second hypothesis, we applied a linear regression model to evaluate the association between trait SPS during the remitted phase and MDI scores during the symptomatic phase for the SAD group alone, correcting for age at baseline, sex, order of assessment, and MDI scores in summer. *P*-values in the mixed-effect models were adjusted by the Bonferroni-Holm multiple comparison procedure (Holm, 1979): *P*-values on analyses trait SPS and its subcomponents were adjusted for five tests, respectively, taking into account that the trait SPS and subcomponents were examined within each set of analyses regarding effects of; group by season, group in summer, group in winter, season for individuals with SAD, and season for healthy controls. Other p-values were reported unadjusted. Model assumptions were evaluated by visual inspection of model residuals and with tests of normality (Shapiro–Wilk $p < 0.05$). Analyses were performed in R (v3.3.0) (R Core Team, 2016) and SPSS (v24.0) with an alpha level of 0.05 (two-tailed).

## 3. Results

### 3.1. Samples characteristics

Demographic information for all participants is listed in Table 1. The SAD and matched control group were not significantly different in terms of sex distribution, age at baseline and education (*p*-values ≥ 0.142). As expected, individuals with SAD presented with significantly higher MDI scores in winter compared to the healthy controls (*p*-values < 0.0001). None of the individuals with SAD suffered from any psychiatric comorbidity, such as a history of non-SAD depressive episodes or symptoms and behaviors related to psychopathology. None of the healthy participants reported clinical levels of depression according to established Danish criteria for clinical cut off scores on the MDI (MDI score ≥ 21 (Olsen et al., 2004)). All HSP Scale scores' residuals were normally distributed, Shapiro-Wilk ≥ .078.

**Table 1**
Sample characteristics.

| Measures | Individuals with SAD ($n$ = 31) | Healthy controls ($n$ = 30) |
|---|---|---|
| Gender, female% *(n)* | 61.3 ± 19 | 53.3 ± 16 |
| Age at baseline, years | 23.9 (12.4) | 26.5 (5.5) |
| Vocational education[a] | 5.0 (2) | 5.0 (1) |
| MDI, summer | 7 (7) | 4 (5) |
| MDI, winter | 24 (8) | 4 (4) |

***Notes:*** Data are shown as median and interquartile range, unless otherwise specified.

[a] Demographic characteristics obtained in summer. Vocational educational scores ranged from 1–5, rated on a 5-point Likert scale from 1 = no vocational education to 5 = academic education > 4 years. SAD = Seasonal Affective Disorder; MDI = Major Depression Inventory.

### 3.2. Sensory processing sensitivity in individuals with SAD compared to healthy controls

Mean scores for trait SPS and its subcomponents; EOE, LST and AES are presented in Fig. 1. Group differences in summer and in winter, seasonal effects for individuals with SAD and healthy controls, and group-by-season differences in trait SPS as well as subcomponents are presented in Table 2. Confirming our first hypothesis, we observed a significant group difference in summer and in winter for trait SPS, where individuals with SAD reported higher scores for trait SPS compared to healthy controls. These group effects in summer and in winter were also observed for EOE, LST and AES, supporting the bifactor model of SPS suggested by Lionetti et al. (2018). Even though, the group-by-season interaction was only marginally significant ($p = 0.037$ when unadjusted for multiple comparisons), individuals with SAD significantly increased in trait SPS and in subcomponents; EOE and LST from summer to winter, while healthy controls remained stable over the seasons. Adding trait Neuroticism and Extraversion as covariates to our model did not substantively change our results.

Lionetti et al. (2018) provided preliminary cut-off scores for categorising individuals into different sensitivity groups; i.e. low sensitivity (mean SPS scores below 3.71), medium-sensitivity (mean SPS score between 3.71 and 4.66) and high-sensitivity (mean SPS score above 4.66). Based on these cut-off scores, our data show that, when averaged across season, about 25% of the individuals with SAD display high-sensitivity whereas this is only the case for 5% of the healthy controls.

### 3.3. Sensory processing sensitivity in summer and severity of depression

Results for the association between trait SPS during the remitted phase and the severity of depressive symptoms during the symptomatic phase in the SAD group are presented in Fig. 2. Confirming our second hypothesis, we found that higher scores on trait SPS in summer were associated with higher MDI scores in winter ($\beta = 0.60$, $p = 0.024$) for the SAD group alone. When limiting the analysis on trait SPS during the remitted phase and the severity of depressive symptoms during the symptomatic phase to the healthy controls, the association was not significant ($\beta = 0.22$, $p = 0.167$). We also performed supplemental analyses with inclusion of trait Neuroticism in summer as covariates in the regression models (see supplementary figure S1).

## 4. Discussion

This is the first longitudinal study using a seasonally counterbalanced design to examine trait Sensory Processing Sensitivity (SPS) in individuals diagnosed with SAD compared to demographically-matched healthy controls. We provide novel evidence that individuals with SAD exhibit higher scores on trait SPS compared to healthy controls in both summer and winter, and that their scores on trait SPS increase from summer to winter. Thus, compared to healthy controls, individuals with SAD display a cross-seasonal pattern of high sensitivity and responsiveness to environmental, social and internal stimuli, which is more evident during depression in winter. Using reported cut-off scores from Lionetti et al. (2018), we find that about 25% of the individuals with SAD display high-sensitivity whereas this is only the case for 5% of the healthy controls, suggesting that those with SAD are more likely to score high on SPS. Importantly, we also show an association between trait SPS and SAD symptomatology. For individuals with SAD, high scores on trait SPS assessed during the remitted phase in summer is associated with depression severity during the symptomatic phase in winter.

From a "diathesis– stress" perspective, our results suggest that high trait SPS constitutes a SAD trait vulnerability that interact with environmental stressors, e.g., cues related to the winter period, to generate SAD depressive symptoms. Such a trait vulnerability approach is supported by the fact that high trait SPS is present in remission among individuals with SAD, and that higher trait SPS in remission is

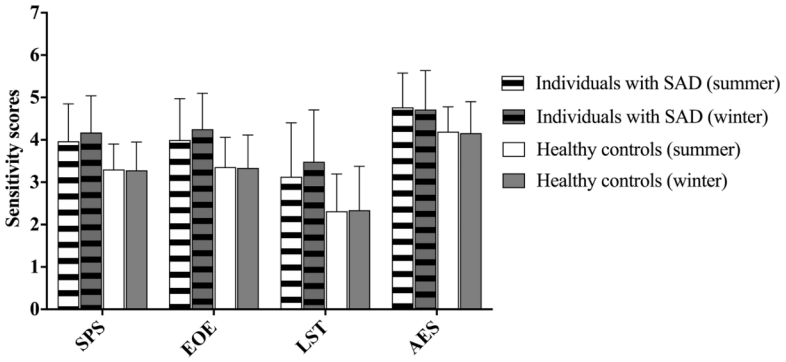


**Fig. 1. Sensory processing sensitivity across groups in summer and in winter.** *Notes:* Mean scores on trait SPS, EOE, LST and AES, respectively for individuals with SAD (n = 31) and healthy controls ($n$ = 30) in summer and in winter. Error bars denote standard deviations. SPS = Sensory Processing Sensitivity, EOE = Ease of Excitation, LST = Low Sensory Threshold, AES = Aesthetic Sensitivity.

**Table 2**
Linear Mixed Effect models for trait SPS and subcomponents.

| | Group effects in summer[a] | | Group effects in winter[b] | | Season effects for individuals with SAD[c] | | Season effects for Healthy controls[d] | | Group-by-season effects[e] | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Variable*** | *Beta coefficients* | *Adjusted p-values*[f] | *Beta coefficients* | *Adjusted p-values*[f] | *Beta coefficients* | *Adjusted p-values*[f] | *Beta coefficients* | *Adjusted p-values*[f] | *Beta coefficients* | *Adjusted p-values*[f] |
| ***SPS*** | 16.92 | 0.01 | 23.49 | 0.00 | 5.72 | 0.03 | −0.85 | 0.70 | 6.57 | 0.07 |
| *EOE* | 7.15 | 0.04 | 10.62 | 0.00 | 3.11 | 0.04 | −0.37 | 0.77 | 3.48 | 0.10 |
| *LST* | 4.49 | 0.05 | 6.62 | 0.00 | 2.17 | 0.05 | 0.04 | 0.96 | 2.13 | 0.15 |
| *AES* | 3.91 | 0.02 | 4.00 | 0.02 | −0.30 | 1.00 | −0.39 | 1.00 | 0.09 | 1.00 |

***Notes:*** Beta coefficients denotes the punctual estimate of the mixed model for a given effect (e.g. group-by-season effect).
[a] Group differences in trait SPS and subcomponents during summer;
[b] Group differences in trait SPS and subcomponents during winter;
[c] Variation across season in SPS and sub-components for individuals with SAD;
[d] Variation across season in SPS and sub-components for healthy controls;
[e] Differences in seasonal variation in SPS and sub-components between the two groups.
[f] *P*-values were adjusted by the Bonferroni-Holm multiple comparison procedure (Holm, 1979): *P*-values in analyses on trait SPS and subcomponents were adjusted for five tests, respectively. SPS = Sensory Processing Sensitivity, EOE = Ease of Excitation, LST = Low Sensory Threshold, AES = Aesthetic Sensitivity.

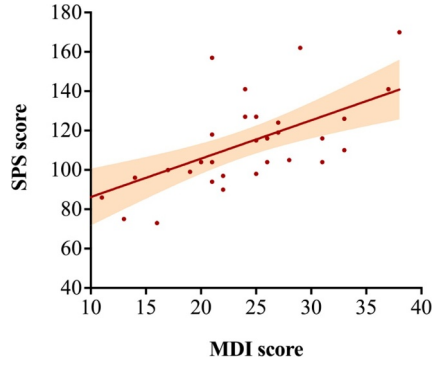


**Fig. 2. Sensory processing sensitivity in summer and depressive symptoms in winter in the SAD group.** *Notes*: Association between scores on trait SPS ($\beta$ = 0.60, $p$ = 0.024) in summer and severity of depressive symptoms during symptomatic phase in individuals with SAD. Values are mean raw scores and shade represent 95% confidence intervals; SPS = Sensory Processing Sensitivity.

associated with more severe SAD. Adding to the "diathesis–stress" perspective, the Integrated Cognitive-Behavioral model of SAD by Rohan (2008) states that the development of SAD occurs, when there are substantial environmental stressors present, which trigger a reverberating cycle between psychological and physiological factors. In line with this model, our results show that SAD is associated, not only to high trait SPS in summer, but also to an increased sensitivity in winter. We speculate that this increase in trait SPS could be related to environmental cues such as colder and darker days, leaves turning brown and fall foliage, which may shift brain biology towards an increased attention to, and the processing of winter-related stress, which is then experienced as more intense and overwhelming. This is in line with findings from several functional magnetic resonance imaging studies, showing a positive association between trait SPS and the activation of brain regions involved in e.g. visual attention and visual processing (Acevedo et al., 2014; Aron et al., 2010; Jagiellowicz et al., 2011). Additionally, in a recent positron emission tomography study of SAD, we showed that females with SAD upregulate the serotonin transporter in winter, whereas healthy females downregulate the serotonin transporter (Mc Mahon et al., 2016). Thus, individuals with SAD may exhibit a brain biology that does not appropriately adjust their trait SPS to accommodate the stress of winter, making them more vulnerable in developing symptoms of SAD. Over time, such winter-related adverse experiences may cause negative associations with winter to develop and consequently affect future negative anticipations of winter and maladaptive behaviors during that time of year. This later statement is in agreement with the claim that from birth, those high in trait SPS are unconsciously perceiving and changing their behavior according to their experiences (Aron et al., 2012), and studies demonstrating that individuals with SAD display an increased emotional and psycho-physiological reactivity to light and winter-related stimuli compared to healthy controls (Rohan et al., 2003; Sigmon et al., 2007). Given the focus on SAD in our study design, it is less suited to evaluate the possibility that high environmental sensitivity in individuals with SAD may extend to positive outcomes. With DST in mind, it could be hypothesized that highly sensitive individuals with SAD may also advantage from positive environmental influences to a greater extent, for example psychological interventions (Pluess and Belsky, 2013). How high SPS may be associated with positive outcome of psychotherapy in individuals with SAD, remains to be clarified in future studies. It could also be hypothesized that the interpretations, preferences, and perceptions of winter interacts with high SPS, so that high SPS individuals without SAD with a positive outlook on winter may actually enjoy winter to greater extent than their low SPS counterparts.

We found that higher trait SPS in summer is related to greater severity of depression in winter. Behavioral disengagement may partially

explain this association, since individuals with SAD who experience higher trait SPS may feel a greater need to withdraw from social activities during winter, as a way to reduce environmental and social overstimulation and avoid stressful situations. However, such a strategy may also reinforce a drift further into withdrawal and depression during winter. Generally, individuals with SAD engage in fewer activities (i.e. behavioral disengagement) in winter compared to summer relative to healthy controls and they report them as less enjoyable in fall or winter compared to summer (Rohan et al., 2003). We have also shown that they decrease in trait Extraversion scores from summer to winter, while healthy controls remain stable (Hjordt et al., 2018). However, based on our data, we cannot address whether behavioral disengagement, less frequent positive emotions and a seasonal decrease in trait Extroversion is a consequence of high sensitivity or decreased energy and increased fatigability, which also characterize SAD (WHO, 1994). Future research on SAD and trait SPS is needed to disentangle these interpretations.

From a clinical perspective, our findings could encourage clinicians to pay careful attention to trait SPS-related challenges in individuals with SAD. Identifying individuals with SAD that exhibit higher levels of trait SPS in summer could serve as an important psychotherapeutic target, for example through psychoeducation and coping skills training. Especially training in more appropriate ways of reducing stress and sensory overstimulation, including inner imagery to promote stillness and optimal stimulation of the senses (as practiced in music therapy (Grocke and Moe, 2015) or meditation and yoga (Evers et al., 2008).

### 4.1. Methodological considerations

This study has several strengths. First, we utilized a longitudinal and seasonally counterbalanced study design. None of our study individuals diagnosed with SAD had received Bright Light Therapy or psychotropic drugs during the course of the study or within the past year. They also presented with full remission in summer. Secondly, we adjusted for summer levels of depressive symptoms in the analyses regarding the association between trait SPS during the remission and depressive symptoms during the symptomatic phase. This eliminates the potential indirect relationship between trait SPS and subsequent depression severity in the symptomatic phase through levels of depression in the remitted phase. However, our results should be interpreted in light of the following limitations. Firstly, we have a small sample size, limiting the statistical power to detect other subtle seasonal changes in trait SPS other than those reported. Secondly, we recognize that alternative but related factors during the remitted phase, such as decreased activity and social engagement in summer, could explain why high trait SPS in summer is associated with more severe SAD symptoms in winter. We recommend that this be investigated in future longitudinal studies with larger sample sizes. Thirdly, we used self-report measures to examine trait SPS and depression severity. Bias in sensitivity scores due to self-reporting is a fundamental methodological challenge in research studies applying questionnaires, e.g., data may have been influenced by e.g. response biases of acquiescence or by a systematic manipulation of answers on items (Domino, 2006). Thirdly, individuals who had received psychological, psychiatric or bright light therapy within the past year were excluded from the study. These strict medication and previous psychopathology inclusion criteria allowed us to examine SAD unconfounded by such factors, but they may have biased our sample towards individuals with less severe SAD. However, it is our clinical experience that many individuals diagnosed with SAD often choose to withhold from psychotropic drugs, because they know that their depressive symptoms remit the following spring or summer. It is possible that individuals with severe SAD depression will exhibit even higher levels of sensitivity. Lastly, given our design and despite the fact that SAD is classified as a form of recurrent major depression (WHO, 1994), it was not possible to investigate, whether individuals with non-seasonal depression would exhibit higher trait SPS compared to our sample. However, future studies may shed light on whether high trait SPS is specific to SAD or if it is a characteristic of other types of depression as well.

In summary, we provide novel evidence that individuals diagnosed with SAD exhibit higher trait SPS in both the remitted phase and the symptomatic compared to healthy controls, suggesting that those with SAD are more likely to score high on SPS. Our results also point to higher trait SPS as an important target when identifying individuals vulnerable towards developing more severe SAD symptoms. Thus, including an assessment of trait SPS in psychiatric evaluations may be informative for clinicians and could also enable preventive intervention targeting maladaptive trait SPS traits in SAD.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.12.112.

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