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Self-perceived personality characteristics in seasonal affective disorder and their implications for severity of depression

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ABSTRACT

The personality traits Neuroticism and Extraversion may be involved in the development of seasonal affective disorder (SAD). However, the impact of personality traits on SAD severity and whether such self-reported traits fluctuate with season is unknown. We investigated the association between Neuroticism, as acquired in a symptom-free phase and depression severity in individuals with SAD and seasonal changes in personality traits in individuals with SAD compared to healthy controls. Twenty-nine individuals diagnosed with SAD and thirty demographically matched controls completed the NEO Personality Inventory-Revised and the Major Depression Inventory twice: in summer when individuals with SAD were symptom-free, and in winter when they experienced SAD symptoms. In summer, the groups scored similarly on their personality traits, and the controls did not score any different in winter compared to summer. High scores on Neuroticism in summer was associated with more severe depressive symptoms in winter in SAD individuals. In winter, individuals with SAD scored higher on Neuroticism and lower on Extraversion, both compared to controls and to their own summer scores. Our results support that Neuroticism may represent a vulnerability marker related to SAD, and during a depressive episode Neuroticism and Extraversion may be sensitive markers of SAD pathology.

1. Introduction

The substantial seasonal variation in daylight hours occurring in northern latitude-counties elicits recognisable changes in behaviour, mood and cognition in some individuals (Hjordt et al., 2017a; Rosenthal et al., 1984). In Copenhagen (55°N), approximately 12% of the population reports such changes to a degree that they manifest clinical symptoms of Seasonal Affective disorder (SAD) (Dam et al., 1998). SAD is characterized by season-triggered depressions, which most often develop during autumn-winter and remit the following spring-summer (Rosenthal et al., 1984). While most SAD studies have focused on season-dependent changes in biology such as changes in brain serotonin transporter levels (Mc Mahon et al., 2016), or in environmental light exposure (Hébert, 2010), only a few studies have investigated pre-disposing self-perceived personality characteristics in SAD.

Several models of personality exist, but the Five-Factor Model (FFM) proposed by Costa and McCrae (1985) has gained wide acceptance due to converging evidence of its consensual validation, cross-cultural invariance, and predictive utility (Costa and McCrae, 1985; Ozer and Benet-Martinez, 2006). According to McCrae and Costa (2003), personality can be described in terms of five major personality traits: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, where each trait is constituted by six sub-facets. Research have mainly focused on the personality trait Neuroticism as a putative risk factor for major depression disorder, where high scores on Neuroticism have been found to cause vulnerability to depressive episodes (Christensen and Kessing, 2006; Kotov et al., 2010; Malouff et al., 2005), and to play a role in depression severity (Brown and Rosellini, 2011). Whereas high scores on Neuroticism may also be a vulnerability factor involved in SAD (Young and Yap, 2010), nothing is known about the association between Neuroticism when examined in remitted phase

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(in summer) and the severity of depressive symptoms during a depressive episode in individuals with SAD. Such knowledge may provide important insight into personality processes underlying SAD symptomatology and severity, and into early treatment of SAD (Klein et al., 2011).

Interestingly, evidence suggest that the self-perceived personality profile in SAD is distinct from those observed in other types of mood disorders and in healthy individuals (Young and Yap, 2010). When compared to healthy reference samples and population norms, SAD is associated with a cross-seasonal pattern of higher scores on Neuroticism (Enns et al., 2006; Gordon et al., 1999; Lingjaerde et al., 2001), higher scores on Openness (Bagby et al., 1996; Enns et al., 2006; Gordon et al., 1999), and lower scores on Extraversion (Enns et al., 2006; Lingjaerde et al., 2001). To date, only one SAD study has examined seasonal changes in FFM traits between winter and summer and found that scores on Extraversion, Openness, and Conscientiousness all increased in summer while scores on Neuroticism decreased (Enns et al., 2006). These latter findings suggest that individuals suffering from SAD experience seasonal fluctuations at the very core of their self-perceived personality (Costa et al., 2005). Compared to other subtypes of depression, SAD is uniquely characterized by seasonal fluctuations in affectivity, which makes it a "natural" model to examine trait characteristics versus state-dependent processes within self-perceived personality in individuals with SAD. However, important limitations of existing studies include comparing individuals with SAD to unmatched controls groups or population norm data, which may error actual differences between the groups, using cross-sectional designs and not including relevant covariates such as IQ. Employing a longitudinal design using a demographically matched control group and adjusting for cognitive resources (IQ) is therefore needed to address FFM traits in SAD.

In a longitudinal design, we therefore aim for the first time to investigate the impact of Neuroticism when examined in remission on the severity of depressive symptoms in symptomatic phase. We further aim to examine group and group-by-season differences in FFM traits in individuals diagnosed with SAD compared to age-, gender- and education-matched healthy non-depressed individuals. Based on the existing literature, we hypothesize that:

(1) In individuals with SAD, higher scores on Neuroticism in the remitted (in summer) phase is associated with more severe depressive symptoms in the symptomatic phase (in winter).
(2) Individuals with SAD exhibit higher scores on Neuroticism and Openness and lower scores on Extraversion compared to controls in both summer and winter.
(3) Individuals with SAD differ in their personality trait scores in summer versus winter on the personality traits Neuroticism, Extraversion, Openness, and Conscientiousness whereas controls ratings remain stable.

2. Methods

2.1. Recruitment

Healthy controls and potential individuals with SAD were recruited through Internet and newspaper advertisement. Initial exclusion criteria were age < 18 or > 45 years, past or present neurological, significant somatic or psychiatric illness, other than SAD for potential individuals with SAD, (ICD-10) (WHO, 1994), any form of known retinal pathology, use of photosensitizing medications, 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 lifetime), pregnancy, night shift work, and travels to countries with significantly different latitude six months prior to assessments. Individuals diagnosed with SAD were not allowed to have taken psychotropic drugs or received bright light therapy within the past year.

2.2. Screening procedures and participants

Following initial screening, potential individuals completed a Danish version of the Seasonal Pattern Affective Questionnaire (Rosenthal et al., 1987). The score of each item is summed to obtain the Global Seasonality Score [GSS; range from 0 to 24]. Controls were required to have a GSS ≤ 10 and reporting no problems with seasonality, whereas SAD candidates were required to have a GSS ≥ 11, and a seasonality problem rating of at least moderate (Kasper et al., 1989). A total of 61 participants were included in the study. Two individuals with SAD were excluded from the analyses: One due to missing NEO Personality Inventory-Revised (NEO PI-R) data in summer and one due to missing Body Mass Index (BMI) data in winter. A sensitivity analysis using multiple imputation was conducted including the individual with missing BMI. This did not change the results. Thus, the final sample comprised 59 participants. Of these, 29 met the diagnostic criteria for SAD, which was established by trained psychiatrists; i.e., presented with SAD during winter (November–February) and full remission in summer (May–July). Major depression was confirmed using the ICD-10 diagnostic criteria (WHO, 1994) and the SAD criteria suggested by Rosenthal et al. (1984) was used to confirm a seasonal pattern. All referred candidates also underwent a Schedules for Clinical Assessment in Neuropsychiatry interview (SCAN v2.1) (Wing et al., 1990) to exclude psychiatric comorbidity before inclusion in the study. The remaining 30 participants were included as controls, matched by age, gender and education. The groups were counterbalanced with regard to time of first psychological assessment to counteract confounding of seasonal effects with re-test effects. Subsamples of the study individuals has been used in previous studies by Jensen et al. (2016), Hjordt et al. (2017a, 2017b), and Mc Mahon et al. (2016). The study was carried out in accordance 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 prior to participation.

2.3. Data collection

All included participants underwent a neurological examination prior to psychological assessments in summer and winter. No abnormalities were observed, which was also supported by standard blood tests. Vocational educational scores ranged from 1 to 5 on a scale from 1 (no vocational education) to 5 (academic education > 4 years). Intelligence quotient (IQ) was measured with the Reynolds Intellectual Screening Test (RIST) (Reynolds and Kamphaus, 2003). IQ was assessed at the first psychological assessment for controls, whereas IQ for individuals with SAD was collected during remission.

2.4. Outcomes

2.4.1. NEO personality inventory-revised

All individuals completed the Danish version (Skovdahl et al., 2011) of the NEO PI-R (Costa and McCrae, 1992) in both winter and summer. The NEO PI-R is a self-report inventory, which assesses the five major personality traits: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, and for each trait six concrete sub-facets. The NEO PI-R comprises 240 items, which are rated on a 5-point Likert scale from 0 (strongly disagree) to 4 (strongly agree). The scores of the items loading on each personality domain were summed to a total raw score ranging from 0 to 192, while scores on sub-facets ranged from 0 to 32.

2.4.2. Major Depression Inventory

All individuals completed the Danish version of the Major Depression Inventory (MDI) (Bech et al., 2001) in both summer and winter. The MDI is a self-reported rating scale of depressive symptoms according to DSM-IV and ICD-10 diagnostic criteria. 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 two weeks. Severity score on the MDI ranged from 0 to 50.

2.5. Statistical analyses

Group differences in demographics and clinical data were evaluated with Mann–Whitney *U* tests and Fisher's exact test were used for categorical data. Wilcoxon signed-rank tests were used to evaluate seasonal differences in clinical data. Internal consistency within FFM traits and MDI scores in both groups in summer and winter were examined with Cronbach's alpha (α). The long-term (summer-winter) retest reliability for FFM traits and MDI for controls was examined with Intraclass Correlation Coefficient (ICC) tests, based on two-way random absolute agreement models.

To test our first hypothesis, a linear regression model was used to evaluate the association between Neuroticism scores during remitted phase and the MDI scores during symptomatic phase in the SAD group alone. The model was adjusted for seasonal order of assessment and variables known to be associated with personality, i.e. age, sex, IQ (Skovdahl et al., 2011) and BMI (Stenbaek et al., 2014) (BMI in winter and absolute change in BMI score [absolute ΔBMI = (winter score–summer score)], respectively). A log-likelihood ratio test was used to evaluate significance levels, comparing the full model against the model without the MDI summer score.

To test our second and third hypothesis for each of the five FFM traits, a linear mixed effect model was used to regress effect of group, effect of season and effect of their interaction on the trait in question. 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. The hypothesis of constant variance over season was relaxed by using a seasonal-specific residual variance parameter. Covariates for the linear mixed model analyses included season, seasonal order of assessment and variables known to be associated with personality. i.e. age, sex, IQ (Skovdahl et al., 2011) and BMI (Stenbaek et al., 2014) (BMI in summer and in winter, respectively). Wald tests were obtained from the linear mixed models to evaluate significance levels. Whenever a significant group or group-by-season effect was found, a linear mixed model including the same covariates and variance-covariance structure was fitted on each of the constitutive sub-facets of the trait to tests the hypotheses at sub-facet level.

Model assumptions were evaluated by visual inspection of model residuals and with tests of normality (Shapiro–Wilk $p < 0.05$). Outliers were identified visually with box-and-whisker and by values greater or lower than 1.5 times the interquartile range. Excluding outliers from the analyses did not change the main outcomes.

P-values were adjusted by the Bonferroni-Holm multiple comparison procedure (Holm, 1979): *P*-values in analyses on traits and sub-facets were adjusted for five and six tests, respectively. An alpha level of 0.05 was adopted throughout all analyses. Statistical analyses were performed using SPSS (v24.0) and R (v3.3.0) (R Core Team, 2016).

3. Results

3.1. Samples characteristics

Participants' characteristics and clinical data are listed in Table 1 and mean FFM trait scores are presented in Fig. 1. Comparison of the Danish normative T-scores for the FFM traits (Skovdahl et al., 2011) with T-scores for the five FFM traits for individuals with SAD in our study are presented in Fig. 2. The individuals with SAD and the healthy controls were comparable in terms of sex distribution, age, education and IQ (*p*-values ≥ 0.05). As expected, individuals with SAD had significantly higher MDI scores in winter compared with summer ($p \leq 0.001$). Remission was judged to have occurred in all individuals with SAD, based on clinical evaluations by the psychiatrists. None of the individuals with SAD suffered from any psychiatric comorbidity, including a history of non-SAD depressive episodes. Moreover, none of the controls presented with clinical levels of depression in the winter or summer assessments, according to established Danish criteria for clinical cut off scores on the MDI (MDI scores ≥ 20) (Olsen et al., 2004). For one individual with SAD, IQ score in summer was missing, so for this individual was used the IQ score collected in winter in the analyses.

Table 1
Sample characteristics.

Measures	Individuals with SAD (*n* = 29)	Healthy controls (*n* = 30)
Gender, female% *(n)*	62.1 ± 18	53.3 ± 16
Age, years[a]	26.2 ± 7.2	26.6 ± 7.2
Vocational education[a]	3.8 ± 1.6	4.5 ± 1.1
Intelligence quotient (RIST Index)[a,b]	107.9 ± 7.4	108.7 ± 6.3
BMI, summer	22.8 ± 3.2	22.9 ± 2.9
BMI, winter	22.8 ± 3.5	22.9 ± 2.5
GSS	14.6 ± 2.5	3.8 ± 2.8
MDI, summer	7.0 ± 4.4	4.6 ± 2.8
MDI, winter	23.3 ± 6.7	4.3 ± 3.0

Notes: Data are shown as mean ± standard deviations, unless otherwise specified. [a]Demographic characteristics obtained at the first test. Vocational educational scores ranged from 1 to 5, rated on a 5-point Likert scale from 1 (no vocational education) to 5 (academic education > 4 years). [b]One SAD participant had missing data on Intelligence Quotient (IQ) score in summer; instead we used RIST score collected in winter; SAD = Seasonal Affective Disorder; GSS = Global Seasonality Score; MDI = Major Depression Inventory; RIST = Reynolds Intellectual Screening Test (RIST).

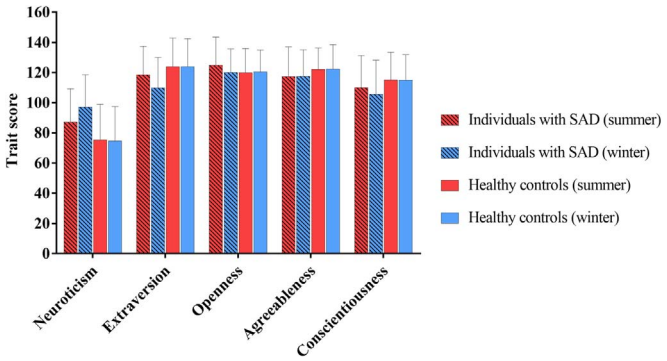

Fig. 1. Mean raw scores on the five FFM traits for individuals with SAD (n = 29) and healthy controls (n = 30) in the summer and the winter. Error bars represent standard deviations.

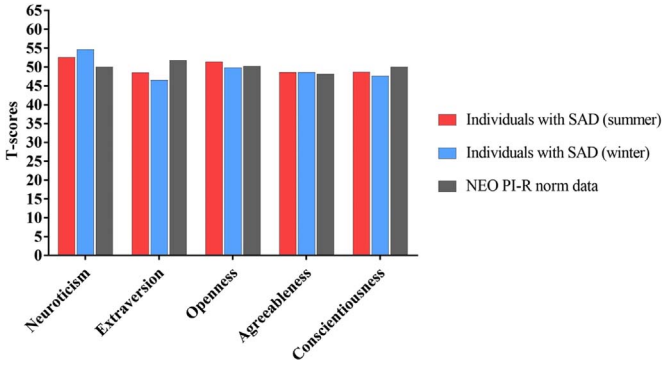

Fig. 2. Comparison of the national normative T-scores for the FFM traits (Skovdahl et al., 2011) with T-scores for the FFM traits for individuals with SAD in our study. The z-scores for the FFM traits for individuals with SAD in our study, are calculated by taking the observation, subtracting it from the mean of all observations and dividing the results from the standard deviation (SD) of all observations.

3.2. Internal consistency and retest reliability

Internal consistency (α) for both groups (individuals with SAD (SAD) or Healthy controls (HC)) in summer ($_s$) and winter ($_w$) ranged from 0.81 to 0.94 for the five FFM traits: Neuroticism (SAD_s = 0.92, SAD_w = 0.91 and HC_s = 0.94, HC_w = 0.93), Extraversion (SAD_s = 0.87, SAD_w = 0.90 and HC_s = 0.91, HC_w = 0.89), Openness (SAD_s = 0.86, SAD_w = 0.81 and HC_s = 0.84, HC_w = 0.81), Agreeableness (SAD_s = 0.89, SAD_w = 0.87 and HC_s = 0.84, HC_w = 0.88), Conscientiousness (SAD_s = 0.90, SAD_w = 0.92 and HC_s = 0.89, HC_w = 0.87) and from 0.58 to 0.76 for MDI scores (SAD_s = 0.76, SAD_w = 0.67 and HC_s = 0.58, HC_w = 0.75). Rest-retest reliability (ICC) for healthy controls ranged from 0.88 to 0.96 (95% confidence intervals (CI), [0.61–0.97]) for the five FFM traits: Neuroticism = 0.94 (95% CI, [0.87–0.97]), Extraversion = 0.93 (95% CI, [0.85–0.97]), Openness = 0.89 (95% CI, [0.76–0.95]), Agreeableness = 0.0.93 (95% CI, [0.85–0.97]), and Conscientiousness = 0.97 (95% CI, [0.93–0.98]) and was 0.87 for MDI scores (95% CI, [0.74–0.94]).

3.3. Effect of Neuroticism in summer on the severity of depression

The association between Neuroticism in remitted phase and severity of SAD during symptomatic phase are presented in Fig. 3. In the SAD group, we found that higher scores on Neuroticism in summer were associated with higher MDI scores in winter ($\beta = 0.14$, $p = 0.04$). When restricting this analysis on the association between Neuroticism in summer and depressive symptoms in winter to the healthy control group, the association was not present, ($\beta = 0.04$, $p = 0.171$).

3.4. Self-perceived personality characteristics in individuals with SAD compared to controls

Group differences in summer and in winter, season effects for individuals with SAD and controls, and group-by-season differences on the five FFM traits as well as sub-facets for significant traits, are presented in Table 2 (and Table 3, Supplemental Material). Seasonal changes in mean Neuroticism scores and mean Extraversion scores in individuals with SAD compared to controls are presented in Fig. 4.

3.4.1. Neuroticism

We observed a significant effect of group in winter for Neuroticism, where individuals with SAD reported higher scores on Neuroticism compared to controls. This group effect was also observed for the Neuroticism sub-facets: Anxiety, Angry hostility, Depression and Vulnerability. We did not observe an effect of group in summer for Neuroticism. We observed a significant group-by-season effect for Neuroticism, where the seasonal change was greater for individuals with SAD compared to controls. This interaction effect was also observed for the Neuroticism sub-facets: Angry hostility, Depression and Vulnerability. The interaction effect was mainly due to a significant increase in Neuroticism from summer to winter in individuals with SAD, while controls remained stable over the seasons.

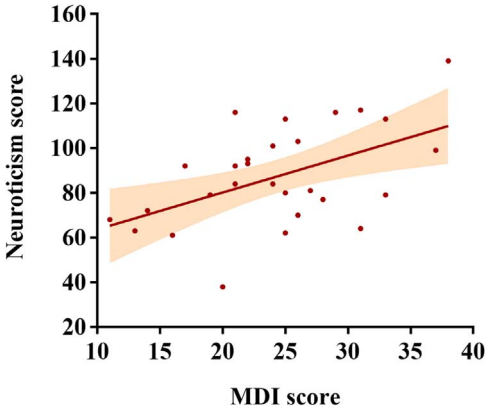

Fig. 3. Association between Neuroticism scores in summer and severity of depressive symptoms during symptomatic phase in individuals with SAD ($\beta = 0.14$, $p = 0.04$). Values are mean raw scores and shade represent 95% confidence intervals; MDI = Major Depression Inventory.

3.4.2. Extraversion

We found a significant effect of group in winter for Extraversion, where individuals with SAD reported lower scores on Extraversion compared to controls. This group effect was also observed for the Extraversion sub-facets: Warmth and Positive emotions. We did not observe an effect of group in summer for Extraversion. We observed a significant group-by-season effect for Extraversion, where the seasonal change was greater for individuals with SAD compared to controls. This interaction effect was also observed for the Extraversion sub-facet: Positive emotions. The interaction effect was mainly due to a significant decrease in Extraversion from summer to winter in individuals with SAD, while controls remained stable over the seasons.

3.4.3. Openness, agreeableness, and conscientiousness

We observed no effect of: group in summer or winter, season or group-by-season for the traits Openness, Agreeableness and Conscientiousness.

4. Discussion

Our results indicate an important relationship between the FFM trait Neuroticism and SAD symptomatology. In particular, for individuals with SAD high scores on Neuroticism examined in remitted phase appear to be relevant to the severity of depression during symptomatic phase. The association between Neuroticism in summer and depressive symptoms in winter was not present in healthy controls. From a "diathesis–stress" perspective, our results suggest that vulnerable individuals with SAD (i.e., those high in Neuroticism during remitted phase) are at higher risk of developing more severe depressive symptoms in response to seasonal changes (i.e., an environmental stressor) during winter. This interpretation is strengthened by the fact that none of the SAD individuals received psychotropic drugs or bright light therapy prior to or during the study that could have influenced the reported personality scores. From a clinical perspective, identifying individuals with SAD with high levels of Neuroticism in summer could serve as an important target when treating individuals psychotherapeutically, for example when offering psychoeducation or coping skills training.

Our design differs from previous studies (Bagby et al., 1996; Enns et al., 2006; Gordon et al., 1999; Lingjaerde et al., 2001), because it is the first longitudinal study with a seasonally counterbalanced design comparing seasonal changes in personality traits in individuals with SAD compared to age-, sex- and education-matched healthy controls. Individuals with SAD scored higher on Neuroticism in winter compared to controls, supporting earlier findings (Enns et al., 2006). In particular, sub-facet level analyses revealed that individuals with SAD were characterized by increased self-reporting of anxiety, angry and hostile attitudes, depression and vulnerability to stress in winter

We did not observe higher scores on Neuroticism in summer compared to controls, which contrast with previous findings reported by Enns et al. (2006); Gordon et al. (1999) and (Lingjaerde et al., 2001). However, these studies may be hampered by some methodological limitations. First, the studies compared individuals with SAD to population norm data (Enns et al., 2006; Gordon et al., 1999) or to an unmatched reference sample (Lingjaerde et al., 2001), which may have introduced a sampling bias. Second, these studies did not control for confounding variables related to personality (e.g. age, sex and IQ). As an exploratory analysis, we compared mean Neuroticism scores in

Table 2
Linear Mixed Effect models for NEO PI-R traits and sub-facets.

	Group by season effects		Group effects in summer		Group effects in winter		Season effects for individuals with SAD		Season effects for Healthy controls	
Variable	*Beta coefficients*	*p*-values[a]	*Beta coefficients*	*p*-values[a]	*Beta coefficients*	*p*-values[a]	*Beta coefficients*	*p*-values[a]	*Beta coefficients*	*p*-values[a]
Neuroticism	10.55	0.03	10.68	0.34	21.23	< 0.00	9.85	< 0.00	−0.70	1.00
Anxiety	2.26	0.10	1.42	0.76	3.69	0.04	1.90	0.05	−0.37	1.00
Angry hostility	1.99	0.04	1.82	0.53	3.81	< 0.00	1.23	0.08	−0.77	0.91
Depression	4.33	< 0.00	2.66	0.53	7.00	< 0.00	4.37	< 0.00	0.03	1.00
Self-consciousness	0.25	0.79	1.70	0.88	1.95	0.18	0.35	0.60	0.10	1.00
Impulsivity	−1.01	0.55	1.60	0.53	0.59	0.57	−0.91	0.34	0.10	1.00
Vulnerability	2.70	0.01	1.41	0.76	4.11	0.01	2.90	< 0.00	0.20	1.00
Extraversion	−8.65	0.01	−5.81	0.41	−14.46	0.02	−8.72	< 0.00	−0.06	1.00
Warmth	−1.31	0.32	−1.17	1.00	−3.02	0.02	−1.40	0.04	−0.10	0.41
Gregariousness	−1.22	0.41	−1.06	1.00	−2.27	0.23	−1.65	0.04	−0.43	1.00
Assertiveness	−1.41	0.41	0.06	1.00	−1.35	0.57	−1.24	0.13	0.17	1.00
Activity	−1.51	0.25	−1.07	1.00	−2.57	0.10	−1.81	0.01	−0.30	1.00
Excitement-Seeking	−0.54	0.51	−0.43	1.00	−0.97	0.57	−0.67	0.25	−0.13	1.00
Positive emotions	−2.68	< 0.00	−1.58	0.75	−4.26	< 0.00	−1.95	< 0.00	0.73	0.99
Openness	−5.26	0.16	4.41	0.70	−0.85	0.81	−4.77	0.03	0.50	1.00
Agreeableness	−0.10	0.97	−6.56	0.41	−6.66	0.16	0.00	1.00	0.10	1.00
Conscientiousness	−4.61	0.16	−5.58	0.70	−10.19	0.14	−4.73	0.02	−0.13	1.00

Notes: Beta coefficients denotes the point estimate of the mixed model for a given effect (e.g. group by season effect). [a]*P*-values were adjusted by the Bonferroni-Holm multiple comparison procedure (Holm, 1979): *P*-values in analyses on traits were adjusted for five test, taking into account that the five FFM traits 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. *P*-values in analyses on sub-facets were adjusted for six tests 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. Degrees of freedom are 55 for all models presented in Table 2.

remitted phase of the individuals with SAD in our study to Neuroticism scores of 600 healthy Danish individuals, reported in the NEO PI-R manual by Skovdahl et al. (2011), using an independent sample *t*-test. We found that individuals with SAD in remitted phase exhibited significantly higher scores on Neuroticism compared to Danish norms (Neuroticism scores in summer 87 ± 22 vs. 77 ± 20, mean ± SD, *p*-values = 0.02), thus replicating previous findings. However, when we compared mean T-scores in summer and in winter for Neuroticism and Extraversion, individuals with SAD were not significantly different from Danish norms (Skovdahl et al., 2011), p-values ≥ 0.18. Two potential problems with this latter comparison is the assumption that mean and SD in our study population are the same as in the general population and that adjustment for confounding variables are not possible.

Taken together, the different conclusions in the literature regarding group differences on Neuroticism in summer may be explained by the statistical approach, e.g. not controlling for confounding variables and the use of unmatched samples. All individuals with SAD were assessed following SAD diagnosis, which requires a seasonal pattern in depressive episodes for at least two consecutive years. In sum, although our data, cannot address whether levels of Neuroticism before SAD depression onset were lower, our results do not suggest that Neuroticism reflect a scarring effect as a result of having had a depression (i.e., having suffered from a depressive episode may to some degree alter a persons' self-perceived personality), since we did not observe significantly higher scores on Neuroticism scores in summer in individuals with SAD compared to controls.

We found that individuals with SAD increased in Neuroticism scores from summer to winter, while controls remained stable over the seasons. In particular, individuals with SAD were characterized by increased self-reporting of angry and hostile attitudes, depression and vulnerability to stress in winter compared to summer compared to controls. This could suggest that these personality traits reflect core vulnerabilities in SAD that are enhanced as winter approaches. The combination of negative attitudes towards winter and having an increased vulnerability profile as winter approaches could potentially be an important causal mechanism in developing new depressive episodes in SAD, which have been suggested by others researchers (Rohan et al., 2009). Corroborating this, individuals with SAD have also been found to exhibit higher emotional and psycho-physiological reactivity to winter-related stimuli compared to controls (Rohan et al., 2003; Sigmon et al., 2007).

Individuals with SAD also exhibited a larger decrease from summer to winter in Extraversion scores including the sub-facet Positive emotions, while controls remained stable across the seasons. These findings

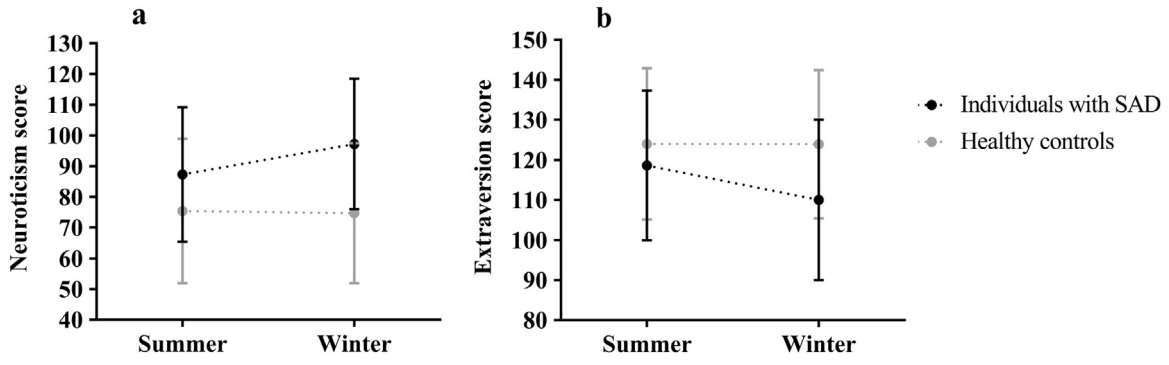

Fig. 4. Seasonal changes in trait Neuroticism and trait Extraversion for individuals with SAD and healthy controls. Values are mean raw scores and the error bars represent standard deviations.

suggest that a social pattern of less frequent positive emotions appear to fluctuate with season in SAD, which parallels findings from previous studies on Extraversion in SAD (Enns et al., 2006) and in major depression (Enns and Cox, 1997). The tendency to express joy, experience happiness and pleasure and to have a high activity level has been proposed to constitute Extraversion at its core (Watson and Clark, 1997; Watson and Naragon-Gainey, 2010) and the decrease in Extraversion in winter may add an important aspect of vulnerability for depressive episodes in SAD because it lowers the rate of positive reinforcement. As such, the self-perceived angry and hostile attitudes towards others, combined with increases in tendency to experience depression, vulnerability and anxiety, may reinforce reduced engagement with the external world as winter approaches (and vice versa), setting the stage for an onset of depression marked by reduced positive emotionality.

In individuals with SAD, we found that scores on Neuroticism and Extraversion varied across season. As previously proposed in the depression literature (Hirschfeld et al., 1983), these season-related changes in self-reported personality scores may reflect a bias in patient rating which may be influenced by their depressed mood state in winter, e.g., tendency to over generalize autobiographic memories (Sumner et al., 2010). Whether the observed seasonal changes in FFM traits in the SAD group reflect temporary influences of depressed state on self-report measurement cannot be addressed with this data. However, if this is the case, it should not necessarily be considered a limitation, as currently depressed individuals with SAD accurately portray their anxiety, and current vulnerability to stress and their lack positive feelings. Rather this should encourage clinicians to use personality data to understand actual changes in the very core of SAD individuals' perceived mind during a depressive episode. As such, profiling FFM traits during a depressive episode in SAD may or may not inform the clinician about the underlying etiology, but could be useful in understanding the patients, developing empathy, offering feedback, and choosing the best treatment (as emphasized by Costa et al. (2005)). In continuation of this, one question is especially relevant: If winter-related changes in trait Neuroticism and Extraversion are central to the development of SAD, can we then stop the depressive process by changing behavioural manifestations of the self-perceived shifts in personality profile? Interestingly, there is evidence that self-perceived personality characteristics can be altered by the hallucinogen psilocybin (MacLean et al., 2011), leaving it an open question as to whether changes in self-perceived personality may also serve as sensitive markers for treatment effect in SAD. Murray et al. (1995) found a positive correlation between Neuroticism and seasonality (i.e. the tendency to experience seasonal variations in mood, sleep, social activity, appetite, body weight and energy), and suggested that seasonality may not stand alone from the more general vulnerability trait of Neuroticism. The notion that seasonality may not stand alone has been supported in skepticism expressed by some researchers regarding SAD as a distinct disorder (Traffanstedt et al., 2016). Future longitudinal studies with larger samples examining personality characteristics in SAD may help clarify the mechanisms that impact on the development and course of SAD. Furthermore, greater attention to Neuroticism in relation to symptom severity may significantly benefit psychopathology research and clinical practice. For example, studies using e.g. latent construct analyses partitioning variance in measures (e.g. Neuroticism and depressive symptoms) could potentially separate trait from state features in the onset and development of a SAD depressive episode.

4.1. Methodological considerations

A major strength of this study is the longitudinal and seasonally counterbalanced study design, suitable for detecting trait and state features of self-perceived personality in SAD. Second, we included well-characterized individuals with SAD and well-matched control individuals. Third, *p*-values in analyses on traits and sub-facets were adjusted by the Bonferroni-Holm multiple comparison procedure, thus lowering the number of false positive findings.

However, our results must be interpreted in the context of some methodological considerations. First, examination of personality traits and depressive symptoms were measured subjectively with self-report questionnaires. Biased self-reporting is an intrinsic methodological concern in questionnaire-based research; i.e., data may be affected by response biases of acquiescence, social desirability and situational aspects, or by a systematic manipulation of answers on items (Domino, 2006). However, studies on self-report and spouse rating data on the NEO PI-R questionnaire supports the validity of the traits measured (Costa and McCrae, 2005). Second, to utilize SAD as a naturalistic model, we excluded individuals treated with antidepressant medication or who received bright light therapy within the past year. Thus, there is a possibility that our sample was biased towards individuals with less severe SAD. However, it is our clinical experience that individuals with SAD often choose to abstain from psychopharmacological interventions, perhaps due to the reversible and predictive nature of the depressive episodes. The fact that individuals with SAD were symptom-free during summer and medication-free during the study and did not receive bright light therapy or psychotropic drugs is valuable from a research perspective prioritizing homogeneous study populations. Third, the relatively small sample size may have limited our statistical power to detect more subtle seasonal changes in self-perceived personality characteristics beyond the findings from the present study.

Our results point to the value of utilizing scores on Neuroticism during remitted phase to identify individuals vulnerable for developing more severe SAD depressions. In addition, during a depressive episode Neuroticism and Extraversion may be sensitive markers of SAD pathology. Thus, including personality assessment in psychiatric evaluations may be informative and could enable preventive psychological intervention targeting behavioural manifestations of such personality traits in SAD.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.psychres.2018.02.015.

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