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No evidence of seasonal variation in mild forms of depression

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ABSTRACT

Background and objectives: Seasonal Affective Disorder (SAD) is ubiquitous in popular culture and has influenced psychiatric diagnosis with the inclusion of the seasonal pattern modifier for the Major Depressive Episode in DSM. However, recent research has not supported the association of Major Depressive Episode with seasonal changes. The present study was conducted to determine if a seasonally-related pattern of occurrence of mild variants of depression could be demonstrated in a population-based study.

Methods: This is a cross-sectional U.S. survey of adults who completed the PHQ-8 Depression Scale with mild depression defined using a PHQ-8 cut score and a second model based on the DSM-5 diagnosis, Depression with insufficient symptoms. Regression models were used to determine if either variant of mild depression was related to season, latitude, or measures of daylight hours.

Results: Neither measure of mild depression was related to daylight hours or its proxy measures.

Limitations: Screening instruments for depression, even if consistent with DSM-5 diagnostic criteria, do not allow a formal diagnosis of depression or the exclusion of similar-appearing disorders. Current depression symptoms but not duration of depressive episode is measured.

Conclusions: Mild depression is not related to seasonal changes or proxy measures of light exposure. The findings cast doubt on light deficiency as a causal factor of depressive disorders, which underpins the inclusion of the seasonal pattern modifier in DSM-5 and light supplementation as a treatment modality.

1. Introduction

In 1984, the construct of Seasonal Affective Disorder (SAD) was introduced as a type of depression that regularly occurs in the fall and winter seasons among some individuals with relapsing forms of the disorder (Rosenthal et al., 1984). It is hypothesized that among people with SAD, regular and complete remission of symptoms typically follows in spring and summer months. A standalone diagnosis of SAD has never been formally introduced into any version of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 1987, 2000, 2013). Rather, DSM-III-R (American Psychiatric Association, 1987) introduced a seasonal pattern modifier that could be added to some affective disorder diagnoses. The decision to include this seasonal pattern modifier was based on the limited number of SAD studies available at the time. The seasonal pattern modifier has been continued in subsequent versions of the DSM with some diagnostic criteria changes (Bauer & Dunner, 1993; Spitzer & Williams, 1989). However, the SAD construct, particularly as measured by the Seasonal Pattern Assessment Questionnaire (SPAQ, Rosenthal, Bradt, & Wehr, 1987), doesn't correspond to the DSM diagnostic criteria for depression. For example, the SPAQ asks respondents to recall if mood or appetite "change with the seasons," whereas the DSM-5 criteria require symptoms such as depressed mood or difficulty with thinking/concentration (American Psychiatric Association, 2013). The SAD construct has also been more commonly characterized by atypical depression symptoms such as carbohydrate craving and hypersomnia, rather than appetite loss and insomnia (Rosenthal, Genhart, Jacobsen, Skwerer, and Wehr, 1987).

A worldwide research literature on SAD has developed over the past three decades on epidemiology (Blazer, Kessler, & Swartz, 1998; Booker & Hellekson, 1992; Kasper, Wehr, Bartko, Gaist, & Rosenthal, 1989; Levitt, Boyle, Joffe, & Baumal, 2000; Rosen et al., 1990), etiology (Lewy & Sack, 1988; Rosenthal et al., 1988); diagnosis (Eagles, 2004; Reeves, Rohan, Langenberg, Snitker, & Postolache, 2012), and treatment (Mårtensson, Pettersson, Berglund, & Ekselius, 2015; Rohan et al., 2015; Terman et al., 1989). SAD is reported to develop in vulnerable individuals when availability of and exposure to natural sunlight during winter months is diminished (Magnusson & Boivin, 2003; Partonen & Lönnqvist, 1998).

Because of the differences between SAD and DSM depression with seasonal pattern, some studies, particularly those using instruments based on the symptoms of depression, have produced unexpected

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results. Studies using DSM symptoms of depression usually produce lower prevalence estimates of seasonal depression than studies that use the SPAQ (Blazer et al., 1998; Levitt & Boyle, 2000; Murray, 2004; Steinhausen, Gundelfinger, & Winkler-Metzke, 2009) or fail to find any seasonal variation at all (Levitt et al., 2000; Magnusson, Axelsson, Karlsson, & Oskarsson, 2000; Mersch, Middendorp, Bouhuys, Beersma, & van den Hoofdakker, 1999a; Nillni, Rohan, Rettew, & Achenbach, 2009; Traffanstedt, Mehta, & LoBello, 2016). Looking generally at these studies, it is reasonable to suppose that the seasonal relationship to depression weakens or disappears when investigated with instruments other than the SPAQ and when expectations about seasonal depression are not communicated to respondents. These findings raise questions about the original decision to create a seasonally recurrent form of depression in DSM based on research of the SAD construct.

There have been efforts to develop instruments for measuring seasonally recurrent depression that improve upon the SPAQ by asking respondents to report on actual symptoms of depression, rather than simply asserting that mood changes with seasons. However, instruments such as the Seasonal Assessment Form (SAF, Young, Hutman, Enggasser, & Meesters, 2015) ask about depression symptoms experienced specifically in winter. The Seasonal Health Question (SHQ, Thompson & Cowan, 2001) asks respondents to report the season during which episodes of depression were most common. Such instruments rely on recall of past seasonal occurrences of depression to establish a diagnosis. This practice is sensible and realistic in a clinical setting, but it is less than sound in attempting to establish the existence of a seasonally recurrent subtype of depression.

There has been substantial research effort to determine if recurrent forms of depression less severe than major depression may also show patterns of seasonal variation. The DSM-5 restricts use of the seasonal pattern modifier to the diagnoses of major depression and bipolar disorder (American Psychiatric Association, 2013). DSM-IV-TR included a proposed diagnostic category of minor depression (American Psychiatric Association, 2000) and, with some modification, minor depression is included in DSM-5 as Depression with insufficient symptoms (American Psychiatric Association, 2013, pp. 183–184). The 10th revision of the International Classification of Diseases does permit diagnosis of a mild form of depression (2 or 3 depression symptoms) using the Recurrent depressive disorder, current episode mild category (F-33, ICD-10; World Health Organization, 1992). Recurrent depressive disorders of any level of severity may be seasonal depressive disorders.

It has been reported that 14% of the U.S. adult population experiences a milder SAD variant called “winter blues” (Rosenthal, 2006; Targum & Rosenthal, 2008).When tied specifically to the SPAQ, this SAD variant is often referred to as subsyndromal SAD (S-SAD; Kasper, Rogers, et al., 1989; Magnusson, 1996; Steinhausen et al., 2009). There is considerable research interest in mild or subsyndromal depression (Pietrzak et al., 2013) as well as interest in determining if mild depression recurs seasonally (Levitt, Lam, & Levitan, 2002).

The purpose of this study was to investigate the possibility of a seasonal pattern in mild variants of depression. There is an endemic level of depressive symptomatology in the population owing to a variety of clinical entities (e.g., Major Depression, Dysthymia). Entering the fall and winter months, the population level of depressive symptomatology should increase above this endemic level as symptoms emerge from the seasonally related cases of depression. As in Traffanstedt et al. (2016), we analyzed Behavioral Risk Factor Surveillance System data, which provided a measure of depression that is consistent with DSM-5 criteria and is administered in a double-blind manner to a large, population representative sample. We considered two definitions of mild depression in our analyses: one based on a Patient Health Questionnaire-8 (PHQ-8, Kroenke & Spitzer, 2002) cut-score and another based on the DSM-5 diagnostic criteria for Depression with insufficient symptoms.

2. Method

2.1. Materials and procedure

The current study was exempt from review by the Institutional Review Board at Auburn University at Montgomery.

The BRFSS is an annual health survey that collects information regarding health risk behaviors, healthcare access, and disease prevention measures (Centers for Disease Control and Prevention, 2013). The BRFSS uses random-digit dialing telephone survey in the United States at the state level (including territories) to gather data about current risk behaviors and health practices (CDC, 2013). We used the 2006 BRFSS data set for this study because a large number of states (i.e., 36) administered the Anxiety and Depression Module as part of the standard survey (Centers for Disease Control and Prevention, 2007). This module includes the Patient Health Questionnaire-8 (PHQ-8) depression scale (Kroenke et al., 2009; Kroenke & Spitzer, 2002).

The Selected Metropolitan/Micropolitan Area Risk Trends (SMART), a subset of the 2006 BRFSS data set, was created to provide county-level estimates of health behaviors and risks within metropolitan (50,000 + population) or micropolitan (at least 10,000 but less than 50,000 population) statistical areas (Centers for Disease Control and Prevention, 2011). The SMART data set utilized in this study included data from 21 states (63 counties) that had administered the PHQ-8. The analyses were conducted using two different definitions of mild depression as described below.

2.2. Participants: PHQ-8 minor depression cut-score model

To identify cases of minor depression based on PHQ-8 scores, we followed the scoring algorithm presented in Fan et al. (2009). Responses to PHQ-8 items are given as number of days during the past two weeks that a symptom of depression was experienced. The scoring model classifies responses as follows: 0–1 day = “not at all”; 2–6 days = “some days”; 7–11 days = “more than half of the days”; and 12–14 days = “nearly every day.” The “not at all” response category was assigned 0 points, with 1, 2, and 3 points assigned to responses moving up the severity dimension. These scores are then summed to provide a PHQ-8 total score that ranges from 0 to 24. The authors of this algorithm specify that individuals scoring between 5 and 9 (inclusive) on this scale are classified as experiencing mild depression (Fan et al., 2009).

Of the 34,876 survey respondents, 34,294 had complete data (Traffanstedt et al., 2016). A subsample of 5488 met the PHQ-8 cut-score criterion for minor depression. Table 1 summarizes demographic information about the subsample of respondents whose PHQ-8 scores were within the minor depression range based on the cut-score model.

2.3. Participants: DSM-5 depressive episode with insufficient symptoms model

The DSM-5 indicates that Depressive episode with insufficient symptoms may be diagnosed in individuals who present with depressed mood and at least one of the other symptoms for depression, accompanied by subjective distress or functional impairment and lasting at least two weeks (American Psychiatric Association, 2013). Individuals who met the criteria under the cut-score model were screened to determine if they endorsed the depressed mood item at least two days out of the previous 14. Table 1 presents sample characteristics for the respondents whose data were used in this analysis.

2.4. PHQ-8 depression scale

The PHQ-8 is an instrument that assesses Major Depressive Episode in accordance with DSM-5 diagnostic criteria except that it does not include an item about suicidal ideation (Kroenke & Spitzer, 2002). The

Table 1
Demographic characteristics of minor depression samples.

Minor Depression:PHQ-8 (n = 5488)			Depression with Insufficient Symptoms (n = 2555)	
Variable	n	Weighted %	n	Weighted %
Latitude				
Northern	2267	20.8	1038	18.5
Middle	2532	59.4	1204	62.3
Southern	649	19.7	313	19.2
Duration of Sunlight Exposure				
8' – 9'59"	1173	10.3	545	9.6
10' – 11'59"	1850	37.1	863	38.6
12' – 13'59"	1381	34.4	646	34.2
14' or more	1044	18.2	501	17.5
Season				
Spring	1478	29.8	717	28.5
Summer	1412	25.4	639	25.8
Fall	1414	25.1	660	26.3
Winter	1144	19.7	539	19.4
Sex				
Women	3723	42.3	1725	43.9
Men	1725	57.7	830	56.1
Race				
White	3963	56.1	1784	52.3
Black	703	15	358	15
Other Non-Hispanic	176	4.1	88	4
Multi-racial Non-Hispanic	115	2.4	53	2.5
Hispanic	450	21.7	256	25.5
Unknown	41	.7	16	.6
Education				
None or kindergarten	9	.9	8	1.7
Grades 1–8 (elementary)	185	5.4	101	6.8
Grades 9–11 (some high school)	417	8.9	219	10.1
Grade 12/GED (high school)	1585	27	737	25.1
College 1–3 years (some college or technical school)	1534	26.2	723	26.9
College 4 years or more	1712	31.3	766	29.5
Unknown	6	.2	1	0.0
Employment				
Employed for wages	2970	57.4	1427	55.4
Unemployed	314	8.6	181	11.3
A homemaker	436	10.5	207	10.9
A student	137	4.3	65	4.5
Retired	1062	11.6	402	9.2
Unable to work	518	7.5	269	8.7
Unknown	11	.07	4	.05
Marital Status				
Married	2562	49.1	1082	44.9
Divorced	952	11.9	476	12.3
Widowed	664	6.1	284	5.6
Separated	150	2.5	86	3.2
Never Married	932	24.1	521	27
Member unmarried couple	179	6.2	101	6.8
Unknown	9	.1	5	.2

PHQ-8 is a valid and reliable measure of depression (Kroenke et al., 2009; Kroenke & Spitzer, 2002).

PHQ-8 Days scores were used as the criterion variable in data analyses (Dhingra, Kroenke, Zack, Strine, & Balluz, 2011). PHQ-8 Days scores are determined by summing across the 8 item scores, which produces a range from 0 to 112 total symptom days. PHQ-8 Days with a cut-score of 55 total symptom days has a sensitivity of 0.91 and specificity of .99, when compared to scores produced by a *DSM*-based Major Depression-PHQ-8 scoring algorithm (Dhingra et al., 2011). The sample of individuals obtained using the PHQ-8 cut-score criteria produced PHQ-8 Days scores that ranged from 10 to 48 symptom days. Survey respondents selected on the basis of the Depression with insufficient symptoms criteria had PHQ-8 Days scores that ranged from 10 to 49 symptom days.

2.5. Season

Season was constructed as a continuous variable following the method of Kerr et al. (2013). December 21, 2006 was the winter solstice. This date was designated as 0 with successive days serially numbered 1–364. Next, beginning with day 0, we constructed five-day intervals to minimize day-to-day fluctuations in number of cases and reduce the number of days with zero cases. The final season variable consisted of 73 five-day intervals. To detect any seasonal changes in depression scores, we created both the square and cube of this variable to model any quadratic and cubic effects.

2.6. Latitude

We constructed three latitude bands based on residence at the time of the survey, which were labeled northern, middle, and southern latitudes (Traffanstedt et al., 2016). Respondents in the northern latitude band (between 42.3° N to 45.2°N latitudes) lived in Maine, Michigan, Minnesota, New Hampshire, Oregon, Vermont, Wisconsin, and Wyoming. Communities in the middle latitude band (between 32.4°N to 36.1°N latitudes) were located in Alabama, Arkansas, California, Georgia, Mississippi, Nevada, New Mexico, Oklahoma, South Carolina, Tennessee, and parts of Texas. The communities in the southern latitude band (between 27.6°N to 30.4°N latitudes) were in Florida, Louisiana and Texas.

2.7. Daylight hours

The U.S. Naval Observatory website provides daylight in hours and minutes for every day of the year for most U.S. cities and towns (United States Naval Observatory [USNO] & Astronomical Applications Department, 2016). We obtained the sunlight data for each 2006 date for every community in the BRFSS SMART county-level data set. The range of daylight on any date within each latitude band was as follows: Northern latitude ranged from 8 h and 43 min to 15 h and 37 min; middle latitude ranged from 9 h and 42 min to 14 h and 37 min; and the southern latitude ranged from 10 h and 11 min to 14 h and 7 min.

Using interview date, state, and county of residence variables included in the BRFSS SMART data, the latitude variable, and the USNO data on sunlight, we created a 4-category daylight hours variable. We classified respondents into one of four groups based on length of daylight on the date of interview: 1) 8–9 h 59 min; 2) 10–11 h 59 min; 3) 12–13 h 59 min; and 4) 14 h or more of sunlight. Number of respondents within each latitude band, daylight hours category, and season (as categories based on 2006 dates of solstices and equinoxes) of interview are summarized in Table 1.

2.8. Design

The study design is cross-sectional. We first modeled the relationship of depression scores to season, which had been constructed as a continuous variable. If the data reflect seasonal fluctuations in mean depression scores, then a polynomial regression model would yield a significant cubic effect for the season variable.

We designed the second analysis to determine if latitude, season, or their interaction could account for significant variation in depression scores. SAD theory implies an interaction that would manifest as higher depression scores among people living at northern latitudes during winter (minimum daylight) and lower depression scores during summer for people living in the southern latitudes (maximum daylight).

Because latitude and season are proxy variables for daylight hours, it is redundant to include the daylight hours variable in the same model with these variables. Also, within the southernmost latitude band, daylight hours do not drop below 10 h per day. An interaction term

using the categorical daylight hours variable and latitude band yields an empty cell. Thus, we evaluated the relationship of daylight hours with mild depression in separate models.

In each multiple regression model, the PHQ-8 Days score was the criterion variable. Each model included a set of covariates found in previous studies to be associated with depression. Model covariates were age (in years) and age squared, race/ethnicity (6 categories), sex (male, female), educational level (7 categories), marital status (7 categories), and employment status (7 categories). Predictor variables and covariates were entered simultaneously in all regression analyses. The three different models described above were conducted for both versions of the mild depression criterion variable, PHQ-8 cut-score, and Depression with insufficient symptoms.

We used the SAS PROC SURVEYREG module (SAS Institute Inc., 2009), which is designed to analyze data produced by surveys that employ complex sampling methodologies. We weighted all analyses using the BRFSS variable designed for use with the SMART data set (_cntywt). Weighting the analysis adjusts standard errors for sampling effects of nonresponse and number of household telephones. In our analyses we took into account survey design effects, including first sampling stage stratification (state, phone density, geographic region) and clustering of phone numbers.

3. Results

3.1. Season

Table 2 presents the results of the analyses for the relationship of season with mild depression as measured by the PHQ-8. The full model (predictors plus covariates) for PHQ-8 minor depression was statistically significant ($F_{29,\ 5333} = 3.1$, $p < .0001$, $R^2 = 0.05$), as was the full model for Depression with insufficient symptoms ($F_{29,\ 2448} = 35.8$, $p < .0001$, $R^2 = 0.10$). However, neither the quadratic nor the cubic model term for season was statistically significant, indicating that these quantities provide no information beyond the linear function. The results indicate that season was unrelated to mild depression, whether operationalized as PHQ-8 score range or as Depression with insufficient symptoms. Among the covariates, only marital status was related to PHQ-8 mild depression, but marital status, employment, and education were related to Depression with insufficient symptoms. Semipartial R^2 values are presented in Table 2 as estimates of the unique effects of each variable in the models.

3.2. Latitude and season

The second analysis evaluated the interaction effects of season and latitude of residence for each mild depression measure. Table 3 presents the results of these analyses. The models for PHQ mild depression ($F_{31,\ 5333} = 3.0$, $p < .0001$, $R^2 = 0.05$) and Depression with insufficient symptoms ($F_{31,\ 2448} = 36.4$, $p < .0001$, $R^2 = 0.10$) were statistically significant. Neither latitude nor season nor the interaction of these variables was statistically significant. The pattern of significance for the covariates was the same as in the analysis for seasonal effect. Specifically, for the PHQ-8 mild depression model, marital status was statistically significant. Marital status, employment, and education were significantly related to Depression with insufficient symptoms. Table 3 also includes semipartial R^2 values for each variable in the models.

3.3. Daylight hours

The final analyses evaluate the relationship of mild depression with the 4-category daylight hours variable constructed from USNO data. Table 4 presents the results of the PHQ-8 mild depression and Depression with insufficient symptoms models. As with the previous analyses, the PHQ-8 score ($F_{29,\ 5333} = 3.1$, $p < .0001$, $R^2 = 0.05$) and Depression with insufficient symptoms ($F_{29,\ 2448} = 42.3$, $p < .0001$, $R^2 = 0.10$) models were statistically significant. However, as with previous analyses, only the covariates accounted for variance in depression scores. Marital status was the only model variable significantly related to PHQ-8 mild depression scores, and marital status, employment, and education were significantly related to Depression with insufficient symptoms. Daylight hours are unrelated to mild depression. Semipartial R^2 values are included in Table 4.

4. Discussion

The results of this study extend the findings of Traffanstedt et al. (2016), who reported no relationship between major depression and season, latitude of residence, nor a more direct measure of daylight hours. Research has focused on seasonal occurrence of mild depression, and it is possible to diagnose seasonal depression as recurrent mild depression in ICD-10. Therefore, we sought to determine if mild depression operationalized either as a specific score range on the PHQ-8 or as the DSM-5 diagnosis of Depression with insufficient symptoms, shows a seasonal pattern of variation. As with major depression, these mild variants of depression are unrelated to either season, latitude of residence, or daylight hours. These findings have implications for SAD theory and its application to the concept of seasonal depression as

Table 2
Relationship of season to depression scores for the PHQ-8 mild depression and depression with insufficient symptoms groups.

PHQ-8 Mild Depression (n = 5448)				Depression with Insufficient Symptoms (n = 2555)		
Variable	Semi partial r^2 [a]	F	Numerator df [b]	Semi Partial r^2 [a]	F	Numerator df [c]
Season (Days since Winter Solstice)	.0002	1.2	1	.0003	.72	1
$Season^2$	.0003	1.4	1	.0007	1.0	1
$Season^3$	.0004	1.5	1	.001	1.2	1
Age	.008	.7	1	.004	.6	1
Age^2	.009	.08	1	.006	.07	1
Sex	.001	.5	1	.003	1.4	1
Race	.006	.5	5	.01	1.2	5
Education	.01	1.4	6	.04	10.1***	6
Employment	.02	1.4	6	.03	2.5*	6
Marital Status	.02	4**	6	.03	8.2***	6
Full Model $R^2 = .05$				Full Model $R^2 = .10$		

*$p < .05$ **$p < .01$ ***$p < .0001$.
[a] Represents total unique effect for each variable.
[b] Denominator df = 5333.
[c] Denominator df = 2448.

Table 3
Relationship of season and latitude to depression scores for the PHQ-8 mild depression and depression with insufficient symptoms groups.

PHQ-8 Mild Depression (n = 5448)				Depression with Insufficient Symptoms (n = 2555)		
Variable	Semi partial r^2 [a]	F	Numerator df [b]	Semi partial r^2 [a]	F	Numerator df [c]
Days since Winter Solstice (Season)	.0002	.44	1	.0003	.40	1
Latitude	.0006	.92	2	.0003	.44	1
Season * Latitude	.0008	.52	2	.001	.45	2
Age	.008	.68	1	.004	.50	2
Age^2	.009	.07	1	.006	.06	1
Sex	.001	.56	1	.003	1.6	1
Race	.006	.59	5	.01	1.1	5
Education	.01	1.4	6	.04	11***	6
Employment	.02	1.4	6	.03	2.5*	6
Marital Status	.02	3.7**	6	.03	7.9***	6
Full Model R^2 = .05				Full Model R^2 = .10		

*$p < .05$ **$p < .01$ ***$p < .0001$.
[a] Represents total unique effect for each variable.
[b] Denominator df = 5333.
[c] Denominator df = 2448.

Table 4
Relationship of sunlight exposure to the PHQ-8 mild depression and depression with insufficient symptoms groups.

PHQ-8 Mild Depression (n = 5448)				Depression with Insufficient Symptoms (n = 2555)		
Variable	Semi partial r^2 [a]	F	Numerator df [b]	Semi partial r^2 [a]	F	Numerator df [c]
Sunlight Exposure	.004	1.1	3	.005	.55	3
Age	.008	.74	1	.004	.60	1
Age^2	.009	.10	1	.006	.11	1
Sex	.001	.37	1	.002	1.2	1
Race	.006	.65	5	.01	1.2	5
Education	.01	1.2	6	.04	11.5***	6
Employment	.02	1.5	6	.03	2.4*	6
Marital Status	.02	3.9**	6	.03	8.5***	6
Full Model R^2 = .05				Full Model R^2 = .10		

*$p < .05$ **$p < .01$ ***$p < .0001$.
[a] Represents total unique effect for each variable.
[b] Denominator df = 5333.
[c] Denominator df = 2448.

described in DSM-5 (American Psychiatric Association, 2013) and ICD-10 (World Health Organization, 1992). First, proponents of SAD theory generally contend that a reduction in daylight triggers depression in some people (Rosenthal, 2006) and our findings do not support such a relationship. Second, because winter daylight diminishes relative to spring and summer, the number of SAD cases is often reported to be greater in winter, far exceeding the number of cases that have a spring/summer occurrence pattern (e.g., Kasper, Wehr, et al., 1989; Mersch, Middendorp, Bouhuys, Beersma, & van den Hoofdakker, 1999b; Pjrek et al., 2016). Contrary to this claim, we do not see excess mild depression in winter compared to spring and summer. Our findings indicate that the prevalence of mild forms of depression is fairly constant across seasons of the year and latitude of residence.

These findings, and others, challenge us to consider two possible interpretations: a) the prevalence of seasonally recurrent depression is so low that it may not be detected in large scale epidemiological studies or b) there is no depression subtype that follows a seasonally determined, or daylight-related, pattern of recurrence. With respect to prevalence, few researchers claim that SAD is rare. The typical prevalence estimate of SAD given for the U.S. is 6% of the population with 14% having the mild form of SAD (Rosenthal, 2006; Targum & Rosenthal, 2008), which corresponds to mild depression (Gordon, 2016). When scales that conform to the diagnostic criteria for depression are used, prevalence estimates of SAD tend to be much lower. With respect to epidemiological methods, epidemiological investigations have been a mainstay of SAD research and offered as supportive of SAD theory (Kasper, Wehr, et al., 1989; Pjrek et al., 2016; Rosen et al., 1990). Because the milder form of seasonal depression is supposedly more prevalent than the major form, it should be easier to detect using epidemiological methods than the more severe type.

Our studies are not alone in failing to show a relationship between daylight (operationalized as seasons or latitude) and depression (Blazer et al., 1998; Elbi et al., 2002; Grimaldi, Partonen, Haukka, Aromaa, & Lonnqvist, 2009; Kerr et al., 2013; Magnusson et al., 2000; Mersch et al., 1999b; Muscettola et al., 1995; Nillni et al., 2009; Sakamoto, Nakadaira, Kamo, Kamo, & Takahashi, 1995). The studies that generally fail to find a seasonal pattern in depression use instruments that directly assess depression symptoms across seasons, but do not query respondents directly about seasonal occurrences (Kerr et al., 2013; Magnusson et al., 2000; Nillni et al., 2009; Traffanstedt et al., 2016).

Measuring seasonality of depression in most research, and particularly in early research, has been done primarily by response to direct questions about past seasonal experiences of depression (Kasper, Wehr, et al., 1989; Rosen et al., 1990). The SPAQ, the screening instrument that was employed most often in this work, does not reflect DSM diagnostic criteria for depression and it assesses seasonality by directly questioning about seasonal occurrences. The contrast between outcomes of studies that ask directly about seasonal occurrence of depressive episodes versus those that measure depression across seasons without reference to seasonality is striking. Meesters and Gordijn

(2016), commenting on two studies (Traffanstedt et al., 2016; Winthorst, Post, Meesters, Penninx, & Nolen, 2011) remarked that, "if the survey contains no specific relevant questions that relate to the concept of seasonal variations, no relevant answers can be found." (p. 323). We believe that this poses a significant challenge to SAD theory and raises questions about whether depression occurrence is associated with seasonal changes.

Belief in seasonal influences on mood and other psychological processes is common (Brennen, Halll, Verplanken, & Nunn, 2005; Grimaldi et al., 2009; Winthorst et al., 2014). Moreover, some studies have found small but statistically significant seasonal mood fluctuations that do not fall within the depressed range (Harmatz et al., 2000) or are so small as to be of no practical significance (Kerr et al., 2013; Murray, Allen, & Trinder, 2001). We hypothesize that the belief in seasonal influences on mood and the common experience of mild mood fluctuations, some of which may correspond with seasonal changes or weather events, provides an experiential basis for the belief that mood and season are causally linked. The belief in the association of season and mood/depression is routinely reinforced in the media which provide countless informational pieces about seasonal depression. It would be surprising if research conducted within this social/cultural milieu, research that relies on direct questioning about past seasonal episodes of depression, failed to uncover a season-depression association. This is the general methodology that gave rise to the SAD construct and provided the basis for the seasonal pattern modifier to be included in the DSM for use with major depression and bipolar disorder diagnoses. The inclusion of the seasonal pattern modifier for major depression in DSM has indirectly granted official legitimacy to SAD. Subsequently, the belief in a seasonally determined subtype of depression as a clinical and scientific construct was propagated worldwide.

This research concerns the scientific claim that seasonally recurrent variants of mild depression are valid subtypes of depression. Our research suggests that they are not. Epidemiological methods, used initially to provide evidence for the subtype, seem uniquely suited to determine validity, and it is indeed difficult to conceive of an experimental procedure that would bear on this question. Experimental research has been done with respect to treatment, where clinical trials, for example, have failed to show a benefit for bright light therapy over antidepressant medication (Lam et al., 2006) or cognitive behavioral therapy (Rohan et al., 2015). Light therapy has also been found effective in treating nonseasonal major depression (Lam et al., 2016). It has long been recognized that it is difficult to design an adequate placebo condition against which to evaluate bright light therapy in experimental studies (Eastman, 1990). Regardless of the formidable obstacles in designing adequate clinical trials, the lack of clear superiority of bright light treatment over other therapies and placebos also casts doubt on whether light deficiency operates as a causal variable in some depressions.

One key criticism of the research methodology that led to the creation of SAD was the use of instruments that rely upon recall to determine seasonality. Since the creation of the SAD construct, more has become known about the accuracy of recall of past affective states (e.g., Ben-Zeev, Young, & Madsen, 2009). The diagnosis of depression also requires recall of symptoms during the two weeks prior to assessment, and this is the methodology of most depression questionnaires including the PHQ-8 used in this study. Nayyar and Cochrane (1996) identified more cases of SAD using retrospective recall compared to prospective assessment. In recent years, Ecological Momentary Assessment (EMA) methods have been used, particularly in the investigation of depression and other forms of psychopathology, that involve negative affective symptoms (aan het Rot, Hogenelst, & Schoevers, 2012; Silk et al., 2011; Solhan, Trull, Jahng, & Wood, 2009). These techniques employ cell phone or other electronic device technology to collect real-time data from users about current affective state. These methods could be adapted to the study of seasonality in depression. While this technique would not solve all measurement issues, it would eliminate the reliability problems affecting instruments that rely on symptom recall.

4.1. Limitations

Diagnosis of seasonally recurring depression, whether using SAD or DSM-based criteria, requires documentation of depressive episodes during specific consecutive seasons with remission of symptoms when the season changes. Such diagnostic criteria require observation or review of symptom history over two years to capture information about symptomatic and asymptomatic seasons. This study did not identify cases of mild depression to follow prospectively to document seasonality. Proponents of seasonality in depression have not only indicated that the incidence is relatively high, but also that fall/winter onset cases greatly exceed the spring/summer onset cases in number (Kasper, Wehr, et al., 1989; Pjrek et al., 2016; Rosen et al., 1990). Our study, which is observational and cross-sectional in design, and encompasses a single calendar year, is predicated on this claim that a substantial and disproportionate share of the population experiences fall/winter recurrent mild depression, or "winter blues." If this claim is true, then it would be possible to detect the increased number of mild depression cases that rise above the endemic levels of depression during fall/winter seasons. It has been argued that prospective follow-up designs are better suited to study this problem because of the two year time period required to support diagnosis (Winkler et al., 2017). However, the structure of diagnostic criteria is not a methodological constraint and two years of observation are not required to establish a contrast between occurrence of mild depression in spring/summer and fall/winter. Moreover, if the expected rise in cases of mild depression does not occur during the fall/winter seasons of a calendar year, as is the case in our study, then what occurs during the subsequent fall/winter season is moot.

Our approach to the direct measure of daylight has been to link data from the U.S. Naval Observatory to the communities where survey respondents live. The categorical daylight variable that we created is not as fine-grained as the precise measure of sunlight exposure time. Also, the daylight variable is not a measure of actual exposure but of availability of daylight on the day of interview.

In the assessment of depression, our method is a compromise between breadth versus depth. While the PHQ-8 is a reliable and valid instrument based on DSM diagnostic criteria of depression, it operates here as a screening, rather than a diagnostic instrument. The PHQ-8 determines the presence of depressive symptoms, but it does not discriminate among some types of depressive symptoms (e.g., insomnia or hypersomnia) nor identify the time of onset and duration of these symptoms. The PHQ-8 does not distinguish people who experience only depression from those who experience it as part of another psychiatric disorder (e.g., schizophrenia, bipolar disorder, borderline personality disorder). A more in-depth clinical evaluation would permit these finer diagnostic distinctions and possible exclusion of some cases that may not be primarily depressed. Such efforts would involve greater time and expense, possibly reducing the number of participants, and reducing the ability of the study to detect seasonal or light-related changes in depression. Telephone survey methodology is commonly used for population-based surveys and is not inherently flawed. The PHQ-9 depression inventory produces similar results whether administered by telephone or in person (Fine et al., 2013; Pinto-Meza, Serrano-Blanco, Peñarrubia, Blanco, & Haro, 2005). If seasonal depression is as common as claimed, then we believe that the excess cases of depression occurring during winter months would favor detection of a seasonal pattern using these methods and measures.

4.2. Conclusions

A seasonal pattern of depression is less likely to be found in studies that: a) employ instruments that measure current symptoms and are consistent with DSM diagnostic criteria, b) determine seasonal pattern

based on observed cases, rather than recall of past episodes, c) use population-representative samples, and d) collect data in a double-blind fashion. The number of studies that meet some or all of these criteria and that fail to demonstrate seasonal depression is growing (Blazer et al., 1998; Cobb et al., 2014; Hardt & Gerbershagen, 1999; Kerr et al., 2013; A.; Magnusson et al., 2000; Michalak et al., 2004; Nillni et al., 2009; Traffanstedt et al., 2016). Rosenthal has stated that SAD is, "not just a seasonal syndrome, it's a light deficiency syndrome" (Overy & Tansey, 2014). Together with the present study, there is a developing body of evidence indicating that light availability/exposure is not related to the prevalence of depression in either its mild or severe forms.

Conflicts of interest

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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