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Chronotype and Seasonality: Morningness is Associated with Lower Seasonal Mood and Behavior Changes in the Old Order Amish

Layan Zhang^{1,2}, Daniel S. Evans³, Uttam K. Raheja^{1,2}, Sarah H. Stephens⁴, John W. Stiller^{1,2}, Gloria Reeves⁵, Mary Johnson⁶, Kathleen A Ryan⁴, Nancy Weizel⁵, Dipika Vaswani¹, Hassan McLain¹, Alan R. Shuldiner⁴, Braxton D. Mitchell⁴, Wen-Chi Hsueh⁷, Soren Snitker⁴, and Teodor T. Postolache^{1,8,*}

¹Mood and Anxiety Program, University of Maryland School of Medicine, Baltimore, MD, USA

²Saint Elizabeths Hospital, Psychiatry Residency Training Program, Washington, DC, USA

³California Pacific Medical Center Research Institute, San Francisco, CA, USA

⁴Division of Endocrinology, Diabetes and Nutrition, Department of Medicine, University of Maryland School of Medicine, Baltimore, MD, USA

⁵Division of Child and Adolescent Psychiatry & University of Maryland Child and Adolescent Mental Health Innovations Center, University of Maryland School of Medicine, Baltimore, MD, USA

⁶Department of Ophthalmology & Visual Sciences, University of Maryland School of Medicine, Baltimore, MD

⁷Phoenix Epidemiology and Clinical Research Branch, NIDDK, National Institutes of Health, Phoenix, AZ

*Corresponding author at: University of Maryland School of Medicine, Mood and Anxiety Program, Department of Psychiatry, 685 West Baltimore Street, MSTF Building Room 930, Baltimore, MD 21201, USA., Tel.: +1 4107062323; fax: +1 4107060751., teopostolache@gmail.com (T.T. Postolache).

Conflict of interest

The authors declare they have no conflict of interest.

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Contributors:

Dr. Zhang managed the literature searches and part of data analyses, and wrote the first draft of the manuscript. Dr. Postolache obtained funding, designed the study, wrote the protocol, and contributed to the final draft to be circulated to coauthors. Dr. Uttam K. Raheja helped with data collection of the seasonality component and database management. Drs. Sarah H. Stephens and Braxton D. Mitchell undertook the statistical analysis. Drs. Mary Johnson, Gloria Reeves, John W. Stiller and Soren Snitker contributed with major intellectual input to results interpretation. Kathy Ryan, Nancy Weizel and Dr. Dipika Vaswani were instrumental in obtaining seasonality data (selection, inclusion and connecting with the Amish participants). Drs. Alan R. Shuldiner, Wen-Chi Hsueh, Soren Snitker and Daniel Evans obtained the data on chronotype. Dr. Shuldiner also led the overall research program at the University of Maryland Amish Research Clinic. All authors contributed to revisions of intermediate drafts of the manuscript and approved its final form.

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⁸VISN 5 Capitol Health Care Network Mental Illness Research Education and Clinical Center (MIRECC), Baltimore, MD, USA and VISN 19 MIRECC, Denver, Colorado, USA

Abstract

Background—Several studies documented that lower scores on the Morningness-Eveningness Questionnaire (MEQ) are associated with a higher global seasonality of mood (GSS). As in the Modern Man artificial lighting predominantly extends evening activity and exposure to light, and as evening bright light phase is known to delay circadian rhythms, this chronic exposure could potentially lead to both lower Morningness as well as higher GSS. The aim of the study was to investigate if the MEQ-GSS relationship holds in the Old Order Amish of Lancaster County, PA., a population that does not use network electrical light

Methods—489 Old Order Amish adults (47.6% women), with average (SD) age of 49.7(14.2) years, completed both the Seasonal Pattern Assessment Questionnaire (SPAQ) for assessment of GSS, and MEQ. Associations between GSS scores and MEQ scores were analyzed using linear models, accounting for age, gender and relatedness by including the relationship matrix in the model as a random effect.

Results—GSS was inversely associated with MEQ scores ($p=0.006$, adjusted).

Limitations—include a potential recall bias associated with self-report questionnaires and no actual light exposure measurements.

Conclusion—We confirmed the previously reported inverse association between MEQ scores and lower seasonality of mood, for the first time in a population that does not use home network electrical lighting. This result suggests that the association is not a byproduct of exposure to network electric light, and calls for additional research to investigate mechanisms by which Morningness is negatively associated with seasonality.

Keywords

Seasonal Affective Disorder; Amish; Seasonal Pattern Assessment Questionnaire (SPAQ); Global Seasonality Score; Morningness-Eveningness Questionnaire (MEQ)

Introduction

Chronotype refers to an individual's preference for morning or evening activities as a consequence of diurnal variation in physical and cognitive abilities (Mongrain et al., 2004; Stiller and Postolache, 2005). This preference of activities for a particular time of day is regulated in part by the endogenous circadian pacemaker located in the hypothalamic suprachiasmatic nucleus, and by a variety of biological and social environmental stimuli (Klerman, 2005; Takahashi et al., 2008). Chronotype is usually evaluated by a Morningness-Eveningness questionnaire, dividing individuals into three distinct categories, i.e. the morning, intermediate, and evening types (Horne and Ostberg, 1976). A higher score is consistent with Morningness, and a lower score with Eveningness.

Morning types are persons who are more alert and active in the morning. They have a tendency to go to bed early, and wake up and perform better during the early part of the day.

On the other end of the chronotype continuum, evening types have a relatively later schedule with later bed and wake-up times (Biss and Hasher, 2012; Mongrain et al., 2004; Roenneberg et al., 2003). These preferences appear to be predominantly driven by physiological rather than psychological or social factors. Core body temperature minimum (CBTM) and dim light melatonin onset (DLMO), the two most commonly used physiological markers of endogenous circadian rhythmicity, display an earlier phase of rhythm in morning types compared to evening types (Baehr et al., 2000; Bailey and Heitkemper, 2001; Duffy et al., 1999). Chronotypes tend to shift with individual development. While there is considerable individual variability, children tend to have elevated Morningness, with a decrease during puberty and again elevation with advancement in age (Carskadon et al., 1993; Colrain and Baker, 2011; Hagenauer et al., 2009; Roenneberg et al., 2007; Roenneberg et al., 2004).

Seasonality refers to changes in mood and behavior with change of season. Seasonal affective disorder of winter type (SAD) was first described as recurrent depressive episodes occurring in autumn and winter with remission in spring and summer (Rosenthal et al., 1984a). In DSM-5, the essential feature for the diagnosis of depressive disorders with seasonal patterns is the onset and remission of major depressive episodes at characteristic times of a year, which have occurred at least during a 2-year period, without any non-seasonal episodes occurring during this period (American Psychiatric Association, DSM-5 2013). Typical symptoms of SAD include low energy, hypersomnia, hyperphagia (with a predominant increase in carbohydrate craving and intake), weight gain and decreased libido in winter (Jacobsen et al., 1987; Rosenthal et al., 1984b; Rosenthal et al., 1984a; Workman and Nelson, 2011). A milder form of seasonal depression, at times with isolated neurovegetative symptoms (sleep and appetite changes), has been described as sub-syndromal SAD (Kasper et al., 1989).

According to the current literature, lower Morningness/ higher Eveningness are linked with higher seasonality of mood and higher prevalence of seasonal affective disorders (SAD) compared to a non-evening chronotype (Murray et al., 2003; Natale et al., 2005; Tonetti et al., 2012), and an extreme form of Eveningness, Delayed Sleep Phase Syndrome (DSPS), has been associated with syndromal and subsyndromal SAD (Lee et al., 2011).

All previous studies examining the relationship between evening chronotype and seasonality took place in populations using network electrical lighting (lighting powered by the electric grid). It has been shown that because exposure to even low levels of ordinary room light (about 180 lux) can phase-shift circadian rhythms in humans (Boivin et al., 1996; Gooley et al., 2011; Vollmer et al., 2012; Zeitzer et al., 2000; Zeitzer et al., 2005). It follows that exposure to network electrical light during evening hours may play a role in both circadian phase delay and seasonality of mood. If evening light exposure is a key factor in the relationship between evening chronotype and seasonality, the association would be expected to be attenuated in the Older Order Amish, as their exposure to network electrical lighting is prohibited by cultural norms. Previously, we have reported a lower than expected frequency of winter SAD (Raheja et al., 2013) as well as lower than expected frequency of evening chronotype (Evans et al., 2011) in the Amish. We now examine, for the first time in the Amish, associations between chronotype and seasonality of mood.

Methods

We investigated the association between Morningness-Eveningness scores and seasonality in an Amish population from Lancaster County, PA (40°02'23"North, 76°18'16"West). There are approximately 30,000 Old Order Amish in Lancaster County. They constitute a rural and primarily agrarian community (Kraybill, 2008). Their religion prohibits use of certain technologies they perceive as conflicting with their tradition, beliefs and practices (Kraybill, 2008). Among the defining cultural prohibitions, the use of network electrical lighting is forbidden, and is replaced by lower-intensity alternative devices (Scott and Pellman, 1999). Therefore, studying seasonality or chronotype in the Old Order Amish benefits from the possible reduction of the effects of bright electric light exposure during late evening and night hours.

Seasonality of mood was assessed SPAQ administered to 1,306 subjects during 2010–2011, representing a response rate of 57.8% (Raheja et al., 2013). Test-retest reliability of SPAQ in the Amish is adequate. 868 participants completed the Morningness–Eveningness Questionnaire (MEQ) during 2003 – 2006 with a response rate of 89%, including 723 in whom rest-activity was measured with accelerometers, enabling validation of reported Morningness-Eveningness patterns with objectively measured activity levels (Evans et al., 2011). Details on the recruitment of participants have previously been described (Evans et al., 2011; Raheja et al., 2013).

The current analysis is based on 489 subjects (239 women and 250 men), ranging in age from 24 to 87 years) who had completed both the SPAQ and MEQ. The mean age ($\pm$ SD) of the sample was 49.7 ± 14.2 (52.1 ± 14.4 and 47.3 ± 13.7 years for women and men, respectively). The study was approved by the University of Maryland Institutional Review Board (IRB).

Morningness–Eveningness Questionnaire (MEQ)

The MEQ (Horne and Ostberg, 1976) is the most commonly used research tool to assess an individual's chronotype. The MEQ consists of 19 items, and individuals can be scored from 16 to 86. The evening types have the lowest score; morning types have the highest score and the intermediate types are in between. The MEQ can divide individuals in three categories according to their MEQ scores: evening chronotype (16–41), intermediate chronotype (42–58), and morning chronotype (59–86), (Adan and Natale, 2002; Chelminski et al., 1999; Gaspar-Barba et al., 2009). The validity of the MEQ in the Amish population is supported by an association between MEQ scores and activities monitored by accelerometers (Actical), used to determine wake time and bed-time previously reported by our group (Evans et al., 2011).

MEQs in this study were obtained from 2003 to 2006, with 60.3% completed in spring, 20.1% in summer, 9.6% in fall and 10.0% in winter. The season of completion of questionnaire had no effect on the MEQ scores $F(3,738) = 0.177$, $p=0.91$.

Seasonal Pattern Assessment Questionnaire (SPAQ)

The SPAQ, developed by Rosenthal et al. (1984a), is the most widely used retrospective, self-report measure to estimate seasonality of mood and behavior. The SPAQ was designed principally as a screening tool rather than a diagnostic test (Rosenthal et al., 1987). Its test-retest reliability has been shown to be acceptable in the Old Order Amish (Cronbach's $\alpha = 0.87$) (Kuehner et al., 2013). Additionally, when asked about seasonal patterns on SPAQ the Amish participants' responses showed a high degree of consistency, specifically by the presence of mirror images in seasonal distribution of "feeling best" with "feeling worst", "eating least" with "eating most", gaining most weight with losing most weight, and "socializing least" with "socializing most" (Patel et al., 2012). The timing of the administration of the SPAQ had no significant effect on the distribution of GSS scores in cross-sectional (unpublished data) and longitudinal analysis in a subsample of individual with repeat SPAQ administration (Kuehner et al., 2013).

The central component of the SPAQ is Global Seasonality Score (GSS), calculated by adding responses on six-items (sleep length, mood, social activity, weight, energy, and appetite) on a 5 point Likert scale (score for each item: 0–4). Higher values on the GSS correspond to higher mood seasonality.

Statistical analysis

The primary purpose of this analysis was to investigate the association between chronotype and seasonality. To accomplish this, we analyzed associations between GSS scores and MEQ scores using linear models, accounting for the relatedness among individuals by including the relationship matrix in the model as a random effect. The effects of age and sex were accounted for by including them as covariates in the regression model. Analyses were carried out using the SOLAR software program (Texas Biomedical Research Institute, San Antonio, Texas). Significance was set at $p < 0.05$ for all analyses.

Results

The present sample consisted of 382 morning types (78%, 199 men and 183 women), 101 intermediate types (21%, 49 men, 52 women), 6 evening types (1%, 2 men, 4 women). The MEQ scores ranged from 37 to 80 (mean=63.8, SD=7.09). Increasing MEQ scores (morningness) were associated with increasing age ($p < 0.001$), although were not significantly associated with gender. After adjusting for age, sex, and relatedness, MEQ scores negatively correlated with GSS scores (i.e., Morningness negatively correlated with seasonality, $p = 0.006$).

Discussion

We are reporting, for the first time to our knowledge, a negative relationship between GSS and MEQ scores in a population that has limited exposure to network electrical lighting. These results are consistent with previous studies performed in populations regular patients who most likely use network electrical lighting (Lee et al., 2011; Murray et al., 2003; Natale et al., 2005; Tonetti et al., 2012). In these studies, however, the use of grid connected electric light was likely considered self-evident and not reported specifically.

According to the phase shift hypothesis proposed by (Lewy et al., 1987), seasonality and SAD appears to be caused, at least in part, by a phase delay in circadian rhythms relative to the sleep/wake cycle (Terman et al., 2001; Terman and Terman, 2010). Based on the fact that both delayed sleep phase syndrome (DSPS, an extreme form of Eveningness) and SAD, have evidence of delayed circadian rhythm and both can be effectively treated by interventions aiming to phase advance circadian rhythms, such as light in the morning. (Eastman et al., 1998; Lewy et al., 1998; Szeinberg et al., 2006; Terman et al., 1998; Wasdell et al., 2008). Research in diurnal animals confirms that morning and not evening light reverses depression like behavior induced by short photoperiod (Krivisky et al., 2012). However, there is also evidence against circadian phase changes as being a primary mechanism in SAD as well as a necessary and sufficient mediator of light treatment (Checkley et al., 1993; Eastman et al., 1993; Koorengevel et al., 2003; Murray et al., 2005; Rosenthal et al., 1990; Thompson et al., 1997). Previously, a large case control study conducted to investigate the relationship between DSPS and SAD (Lee et al., 2011) found that the proportion of SAD (syndromal and subsyndromal) is higher in patients with DSPS compared to controls. Accordingly, the authors proposed that DSPS and SAD share a common pathophysiological mechanism as a result of a delayed circadian phase (Lee et al., 2011). A circadian phase delay can be induced, exacerbated and perpetuated by exposure to bright light in the evening. Initially, it was believed that only light of high intensity was able to suppress melatonin and shift human circadian rhythms. More recently however, it has been demonstrated that exposure to evening light of even normal indoor intensity (dim room light of 100 lux– 180 lux) can significantly suppress melatonin secretion in humans and phase delay the endogenous circadian pace maker (Boivin et al., 1996; Gooley et al., 2011; Zeitzer et al., 2000; Zeitzer et al., 2005). In addition, lower Morningness/ higher Eveningness appear to be promoted by intense general environmental exposure to light (Vollmer et al., 2012). Therefore, it follows that the previously discovered relationship between evening chronotype and higher mood seasonality (Lee et al., 2011; Murray et al., 2003; Natale et al., 2005; Tonetti et al., 2012) might be mediated by exposure to artificial light. If this were the case, we reasoned, the GSS MEQ association would not be present in the Old Order Amish as in the non-Amish western contemporaneous populations. However, replicating this relationship in the Old Order Amish, suggests that it is not induced or sustained by the exposure to network artificial light in the modern Man.

If not light, exposure to other environmental or genetic effects could mediate associations between GSS and MEQ scores. For instance, circadian clock-related polymorphisms in both circadian rhythm preference and SAD have been previously reported. For instance, morningness and its extreme form, advanced sleep phase disorder (ASPD), have been found to be associated with incompletely dominant single-nucleotide polymorphisms (SNPs) within *Period2* and *CSNK1D* (Toh et al., 2001). Some polymorphisms of *Period3* and *hCLOCK* genes have been described to be linked with Eveningness and delayed sleep phase disorder (DSPS), though there have been inconsistencies among reports (Archer et al., 2003; Chang et al., 2011; Ebisawa et al., 2001; Johansson et al., 2003; Katzenberg et al., 1998; Mishima et al., 2005; Paik et al., 2007; Robilliard et al., 2002). Additionally, polymorphisms of certain circadian clock genes, including *NPAS2*, *Period2*, *BMAL1* (*ARNTL*) and *Period3* are associated with an increased risk for SAD (Kovanen et al., 2010; Lamont et al., 2007;

Partonen et al., 2007). At the intersection between the two domains of interest, *Period2* and *Period3* have been found to increase both susceptibility to SAD and evening diurnal preference (Johansson et al., 2003; Lamont et al., 2007; Partonen et al., 2007).

Our results indicated that the majority of participants had a typology of morning type (78%), with 21% of intermediate type and 1% evening type (no definite evening type), which is very different from the circadian typology reported in non-Amish with intermediate type encompassing more than 50% of the study populations (Adan and Natale, 2002; BaHammam et al., 2011; Fabbri et al., 2007; Lehnkering and Siegmund, 2007). One possible reason is the age factor. The mean age of our sample was 50 years old, while most of the above studies had mean age around 20 years old. As was reported, puberty onset and age are strongly linked to adolescents' drift towards Eveningness, which is switched back to morning typology after adolescence and during adulthood (Carskadon et al., 1993; Roenneberg et al., 2007). As 47% of our sample was older than 50 y.o, and no participant was younger than 25, it may be possible that this age distribution contributed to a low frequency of evening chronotype. Additionally, consistent with previous reports, rural population tend to have an early diurnal preference compared to urban populations (Roenneberg et al., 2007). The Old Order Amish community mainly leads a traditional agrarian lifestyle which requires them to get up early to do field work. Another possible explanation of the higher prevalence of morning type in this Amish community is that they use much less technology than the modern industrialized societies do in daily life. The electronic screen media (computer, television or video games) is becoming the most frequent evening leisure activity in the "English" (i.e. non-Amish) world, potentially associated with delay of sleep onset among the modern population (Alexandru et al., 2006); Furthermore, it has been shown that the use of blue LED light from electronic screen media can suppress melatonin secretion and promote alertness in the evening (Phipps-Nelson et al., 2009; West et al., 2011). Thus, the freedom from modern technology among the Old Order Amish and a rural lifestyle could facilitate their early sleep onset and early wake up, and chronotype orientation towards morning types.

There is convincing evidence that a low MEQ score are associated with a broad spectrum of psychological and psychiatric problems. These include associations with adult ADHD (Voinescu et al., 2012), bipolar disorder (Hakkarainen et al., 2003), substance-use disorders (Reid et al., 2012), and suicidal thoughts/ attempts (Selvi et al., 2011). Several (Chelminski et al., 1999; Gaspar-Barba et al., 2009; Meliska et al., 2011; Merikanto et al., 2013), but not all (Kontinen et al., 2014) studies have reported negative associations between Morningness and *nonseasonal* depression. Morningness is also a positive predictor of on response of *nonseasonal* depression to treatment (Corruble et al., 2014). As we did not obtain depression severity ratings in our participants, we could not determine if seasonality and/or depression (both components of a dual vulnerability model for SAD) (Chotai et al., 2004; Lam et al., 2001; Young et al., 1991) were related to the evening chronotype. Other limitations include not performing actual measurements of light intensity and wavelength in the Amish homes. The Old Order Amish households have traditionally used fuel-based lighting such as kerosene lanterns, propane lamps and candles (Kraybill, 2008) and light intensity in the Amish homes is supposedly inferior to non-Amish ("English") ones.

Both MEQ and SPAQ are retrospective self-report questionnaires, which inevitably incur recall bias. However, the responses on SPAQ appeared to have good test-retest validity (Kuehner et al., 2013), and the MEQ chronotype correlated with wake-up and sleep type according to activity monitoring devices in the Amish sample analyzed (Evans et al., 2011). Our study is also limited by a small sample, possible self-selection bias, and limited generalizability. Despite the aforementioned limitations of the study it provides a unique view of the association between chronotype and seasonality in an environment with assumed limited bright light exposure in the evening. Additionally, the study reaffirms the need for investigating genetic and environmental influences on the association of SAD and DSPS which are common and co-morbid conditions (Lee et al., 2011) that impact academic and occupational functioning in large proportions of the population.

Conclusion

This study revealed a negative GSS/ MEQ association in the Older Order Amish. This finding is probably independent of light exposure as it is concordant with previous studies performed in settings with network electrical lighting exposure. Morningness may reduce vulnerability for ample seasonal changes in mood, and perhaps Seasonal Affective Disorder. This will have to be further investigated in its own right.

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References

- Adan A, Natale V. Gender differences in morningness-eveningness preference. *Chronobiol Int.* 2002; 19:709–720. [PubMed: 12182498]
- Alexandru G, Michikazu S, Shimako H, Xiaoli C, Hitomi K, Takashi Y, Robert WW, Sadanobu K. Epidemiological aspects of self-reported sleep onset latency in Japanese junior high school children. *J Sleep Res.* 2006; 15:266–275. [PubMed: 16911029]
- American Psychiatric Association. *Depressive Disorders, Diagnostic and Statistical Manual of Mental Disorder DSM-5.* 5. American Psychiatric Publishing; 2013. p. 187-188.
- Archer SN, Robilliard DL, Skene DJ, Smits M, Williams A, Arendt J, von Schantz M. A length polymorphism in the circadian clock gene *Per3* is linked to delayed sleep phase syndrome and extreme diurnal preference. *Sleep.* 2003; 26:413–415. [PubMed: 12841365]
- Baehr EK, Reville W, Eastman CI. Individual differences in the phase and amplitude of the human circadian temperature rhythm: with an emphasis on morningness-eveningness. *J Sleep Res.* 2000; 9:117–127. [PubMed: 10849238]
- BaHammam AS, Almistehi W, Albatli A, AlShaya S. Distribution of chronotypes in a large sample of young adult Saudis. *Ann Saudi Med.* 2011; 31:183–186. [PubMed: 21422657]
- Bailey SL, Heitkemper MM. Circadian rhythmicity of cortisol and body temperature: morningness-eveningness effects. *Chronobiol Int.* 2001; 18:249–261. [PubMed: 11379665]

- Biss RK, Hasher L. Happy as a lark: morning-type younger and older adults are higher in positive affect. *Emotion*. 2012; 12:437–441. [PubMed: 22309732]
- Boivin DB, Duffy JF, Kronauer RE, Czeisler CA. Dose-response relationships for resetting of human circadian clock by light. *Nature*. 1996; 379:540–542. [PubMed: 8596632]
- Carskadon MA, Vieira C, Acebo C. Association between puberty and delayed phase preference. *Sleep*. 1993; 16:258–262. [PubMed: 8506460]
- Chang AM, Buch AM, Bradstreet DS, Klements DJ, Duffy JF. Human diurnal preference and circadian rhythmicity are not associated with the CLOCK 3111C/T gene polymorphism. *J Biol Rhythms*. 2011; 26:276–279. [PubMed: 21628555]
- Checkley SA, Murphy DG, Abbas M, Marks M, Winton F, Palazidou E, Murphy DM, Franey C, Arendt J. Melatonin rhythms in seasonal affective disorder. *Br J Psychiatry*. 1993; 163:332–337. [PubMed: 8401962]
- Chelminski I, Ferraro FR, Petros TV, Plaud JJ. An analysis of the “eveningness-morningness” dimension in “depressive” college students. *J Affect Disord*. 1999; 52:19–29. [PubMed: 10357014]
- Chotai J, Smedh K, Nilsson LG, Adolfsson R. A dual vulnerability hypothesis for seasonal depression is supported by the seasonal pattern assessment questionnaire in relation to the temperament and character inventory of personality in a general population. *J Affect Disord*. 2004; 82:61–70. [PubMed: 15465577]
- Colrain IM, Baker FC. Changes in sleep as a function of adolescent development. *Neuropsychol Rev*. 2011; 21:5–21. [PubMed: 21225346]
- Corruble E, Frank E, Gressier F, Courtet P, Bayle F, Llorca PM, Vaiva G, Gorwood P. Morningness-eveningness and treatment response in major depressive disorder. *Chronobiol Int*. 2014; 31:283–289. [PubMed: 24128195]
- Duffy JF, Dijk DJ, Hall EF, Czeisler CA. Relationship of endogenous circadian melatonin and temperature rhythms to self-reported preference for morning or evening activity in young and older people. *J Investig Med*. 1999; 47:141–150.
- Eastman CI, Gallo LC, Lahmeyer HW, Fogg LF. The circadian rhythm of temperature during light treatment for winter depression. *Biol Psychiatry*. 1993; 34:210–220. [PubMed: 8399817]
- Eastman CI, Young MA, Fogg LF, Liu L, Meaden PM. Bright light treatment of winter depression: a placebo-controlled trial. *Arch Gen Psychiatry*. 1998; 55:883–889. [PubMed: 9783558]
- Ebisawa T, Uchiyama M, Kajimura N, Mishima K, Kamei Y, Katoh M, Watanabe T, Sekimoto M, Shibui K, Kim K, Kudo Y, Ozeki Y, Sugishita M, Toyoshima R, Inoue Y, Yamada N, Nagase T, Ozaki N, Ohara O, Ishida N, Okawa M, Takahashi K, Yamauchi T. Association of structural polymorphisms in the human period3 gene with delayed sleep phase syndrome. *EMBO Rep*. 2001; 2:342–346. [PubMed: 11306557]
- Evans DS, Snitker S, Wu SH, Mody A, Njajou OT, Perlis ML, Gehrman PR, Shuldiner AR, Hsueh WC. Habitual sleep/wake patterns in the Old Order Amish: heritability and association with non-genetic factors. *Sleep*. 2011; 34:661–669. [PubMed: 21532960]
- Fabbri M, Antonietti A, Giorgetti M, Tonetti L, Natale V. Circadian typology and style of thinking differences. *Learn Individ Differ*. 2007; 175–180.
- Gaspar-Barba E, Calati R, Cruz-Fuentes CS, Ontiveros-Urbe MP, Natale V, De Ronchi D, Serretti A. Depressive symptomatology is influenced by chronotypes. *J Affect Disord*. 2009; 119:100–106. [PubMed: 19285347]
- Gooley JJ, Chamberlain K, Smith KA, Khalsa SB, Rajaratnam SM, Van Reen E, Zeitzer JM, Czeisler CA, Lockley SW. Exposure to room light before bedtime suppresses melatonin onset and shortens melatonin duration in humans. *J Clin Endocrinol Metab*. 2011; 96:E463–472. [PubMed: 21193540]
- Hagenauer MH, Perryman JI, Lee TM, Carskadon MA. Adolescent changes in the homeostatic and circadian regulation of sleep. *Dev Neurosci*. 2009; 31:276–284. [PubMed: 19546564]
- Hakkarainen R, Johansson C, Kieseppa T, Partonen T, Koskenvuo M, Kaprio J, Lonnqvist J. Seasonal changes, sleep length and circadian preference among twins with bipolar disorder. *BMC Psychiatry*. 2003; 3:6. [PubMed: 12795811]

- Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *Int J Chronobiol.* 1976; 4:97–110. [PubMed: 1027738]
- Jacobsen FM, Wehr TA, Sack DA, James SP, Rosenthal NE. Seasonal affective disorder: a review of the syndrome and its public health implications. *Am J Public Health.* 1987; 77:57–60. [PubMed: 3789239]
- Johansson C, Willeit M, Smedh C, Ekholm J, Paunio T, Kieseppa T, Lichtermann D, Praschak-Rieder N, Neumeister A, Nilsson LG, Kasper S, Peltonen L, Adolfsson R, Schalling M, Partonen T. Circadian clock-related polymorphisms in seasonal affective disorder and their relevance to diurnal preference. *Neuropsychopharmacology.* 2003; 28:734–739. [PubMed: 12655319]
- Kasper S, Rogers SL, Yancey A, Schulz PM, Skwerer RG, Rosenthal NE. Phototherapy in individuals with and without subsyndromal seasonal affective disorder. *Arch Gen Psychiatry.* 1989; 46:837–844. [PubMed: 2774849]
- Katzenberg D, Young T, Finn L, Lin L, King DP, Takahashi JS, Mignot E. A CLOCK polymorphism associated with human diurnal preference. *Sleep.* 1998; 21:569–576. [PubMed: 9779516]
- Klerman EB. Clinical aspects of human circadian rhythms. *J Biol Rhythms.* 2005; 20:375–386. [PubMed: 16077156]
- Kontinen H, Kronholm E, Partonen T, Kanerva N, Mannisto S, Haukkala A. Morningness-eveningness, depressive symptoms, and emotional eating: a population-based study. *Chronobiol Int.* 2014; 31:554–563. [PubMed: 24417521]
- Koorengevel KM, Beersma DG, den Boer JA, van den Hoofdakker RH. Mood regulation in seasonal affective disorder patients and healthy controls studied in forced desynchrony. *Psychiatry Res.* 2003; 117:57–74. [PubMed: 12581821]
- Kovanen L, Saarikoski ST, Aromaa A, Lonnqvist J, Partonen T. ARNTL (BMAL1) and NPAS2 gene variants contribute to fertility and seasonality. *PLoS One.* 2010; 5:e10007. [PubMed: 20368993]
- Kraybill. *The Amish of Lancaster County.* Stackpole Books; Mechanicsburg, PA: 2008.
- Krinsky K, Einat H, Kronfeld-Schor N. Effects of morning compared with evening bright light administration to ameliorate short-photoperiod induced depression- and anxiety-like behaviors in a diurnal rodent model. *J Neural Transm.* 2012; 119:1241–1248. [PubMed: 22407379]
- Kuehner RM, Vaswani D, Raheja UK, Sleemi A, Yousufi H, Mohyuddin H, Postolache N, Nijjar GV, Postolache TT. Test-retest reliability of the Seasonal Pattern Assessment Questionnaire in Old Order Amish. *Int J Disabil Hum Dev.* 2013; 12:87–90. [PubMed: 23565353]
- Lam RW, Tam EM, Yatham LN, Shiah IS, Zis AP. Seasonal depression: the dual vulnerability hypothesis revisited. *J Affect Disord.* 2001; 63:123–132. [PubMed: 11246088]
- Lamont EW, Legault-Coutu D, Cermakian N, Boivin DB. The role of circadian clock genes in mental disorders. *Dialogues Clin Neurosci.* 2007; 9:333–342. [PubMed: 17969870]
- Lee HJ, Rex KM, Nievergelt CM, Kelsoe JR, Kripke DF. Delayed sleep phase syndrome is related to seasonal affective disorder. *J Affect Disord.* 2011; 133:573–579. [PubMed: 21601293]
- Lehnkering H, Siegmund R. Influence of chronotype, season, and sex of subject on sleep behavior of young adults. *Chronobiol Int.* 2007; 24:875–888. [PubMed: 17994343]
- Lewy AJ, Bauer VK, Cutler NL, Sack RL, Ahmed S, Thomas KH, Blood ML, Jackson JM. Morning vs evening light treatment of patients with winter depression. *Arch Gen Psychiatry.* 1998; 55:890–896. [PubMed: 9783559]
- Lewy AJ, Sack RL, Miller LS, Hoban TM. Antidepressant and circadian phase-shifting effects of light. *Science.* 1987; 235:352–354. [PubMed: 3798117]
- Meliska CJ, Martinez LF, Lopez AM, Sorenson DL, Nowakowski S, Parry BL. Relationship of morningness-eveningness questionnaire score to melatonin and sleep timing, body mass index and atypical depressive symptoms in peri- and post-menopausal women. *Psychiatry Res.* 2011; 188:88–95. [PubMed: 21237517]
- Merikanto I, Lahti T, Kronholm E, Peltonen M, Laatikainen T, Vartiainen E, Salomaa V, Partonen T. Evening types are prone to depression. *Chronobiol Int.* 2013; 30:719–725. [PubMed: 23688117]
- Mishima K, Tozawa T, Satoh K, Saitoh H, Mishima Y. The 3111T/C polymorphism of hClock is associated with evening preference and delayed sleep timing in a Japanese population sample. *Am J Med Genet B Neuropsychiatr Genet.* 2005; 133B:101–104. [PubMed: 15578592]

- Mongrain V, Lavoie S, Selmaoui B, Paquet J, Dumont M. Phase relationships between sleep-wake cycle and underlying circadian rhythms in Morningness-Eveningness. *J Biol Rhythms*. 2004; 19:248–257. [PubMed: 15155011]
- Murray G, Allen NB, Trinder J. Seasonality and circadian phase delay: prospective evidence that winter lowering of mood is associated with a shift towards Eveningness. *J Affect Disord*. 2003; 76:15–22. [PubMed: 12943929]
- Murray G, Michalak EE, Levitt AJ, Levitan RD, Enns MW, Morehouse R, Lam RW. Therapeutic mechanism in seasonal affective disorder: do fluoxetine and light operate through advancing circadian phase? *Chronobiol Int*. 2005; 22:937–943. [PubMed: 16298778]
- Natale V, Adan A, Scapellato P. Are seasonality of mood and eveningness closely associated? *Psychiatry Res*. 2005; 136:51–60. [PubMed: 16023219]
- Paik JW, Lee HJ, Kang SG, Lim SW, Lee MS, Kim L. CLOCK gene 3111C/T polymorphism is not associated with seasonal variations in mood and behavior in Korean college students. *Psychiatry Clin Neurosci*. 2007; 61:124–126. [PubMed: 17239050]
- Partonen T, Treutlein J, Alpmann A, Frank J, Johansson C, Depner M, Aron L, Rietschel M, Wellek S, Soronen P, Paunio T, Koch A, Chen P, Lathrop M, Adolfsson R, Persson ML, Kasper S, Schalling M, Peltonen L, Schumann G. Three circadian clock genes *Per2*, *Arntl*, and *Npas2* contribute to winter depression. *Ann Med*. 2007; 39:229–238. [PubMed: 17457720]
- Patel F, Postolache N, Mohyuddin H, Vaswani D, Balis T, Raheja UK, Postolache TT. Seasonality patterns of mood and behavior in the Old Order Amish. *Int J Disabil Hum Dev*. 2012; 12:53–60. [PubMed: 23667796]
- Phipps-Nelson J, Redman JR, Schlangen LJ, Rajaratnam SM. Blue light exposure reduces objective measures of sleepiness during prolonged nighttime performance testing. *Chronobiol Int*. 2009; 26:891–912. [PubMed: 19637049]
- Raheja UK, Stephens SH, Mitchell BD, Rohan KJ, Vaswani D, Balis TG, Nijjar GV, Sleemi A, Pollin TI, Ryan K, Reeves GM, Weitzel N, Morrissey M, Yousufi H, Langenberg P, Shuldiner AR, Postolache TT. Seasonality of mood and behavior in the Old Order Amish. *J Affect Disord*. 2013; 147:112–117. [PubMed: 23164460]
- Reid KJ, Jaksa AA, Eisengart JB, Baron KG, Lu B, Kane P, Kang J, Zee PC. Systematic evaluation of Axis-I DSM diagnoses in delayed sleep phase disorder and evening-type circadian preference. *Sleep Med*. 2012; 13:1171–1177. [PubMed: 22910327]
- Robilliard DL, Archer SN, Arendt J, Lockley SW, Hack LM, English J, Leger D, Smits MG, Williams A, Skene DJ, Von Schantz M. The 3111 Clock gene polymorphism is not associated with sleep and circadian rhythmicity in phenotypically characterized human subjects. *J Sleep Res*. 2002; 11:305–312. [PubMed: 12464098]
- Roenneberg T, Kuehnle T, Juda M, Kantermann T, Allebrandt K, Gordijn M, Mellow M. Epidemiology of the human circadian clock. *Sleep Med Rev*. 2007; 11:429–438. [PubMed: 17936039]
- Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, Mellow M. A marker for the end of adolescence. *Curr Biol*. 2004; 14:R1038–1039. [PubMed: 15620633]
- Roenneberg T, Wirz-Justice A, Mellow M. Life between clocks: daily temporal patterns of human chronotypes. *J Biol Rhythms*. 2003; 18:80–90. [PubMed: 12568247]
- Rosenthal, NE.; Bradt, GH.; Wehr, TA. Seasonal Pattern Assessment Questionnaire (SPAQ). National Institute of Mental Health; Bethesda, MD: 1984b.
- Rosenthal, NE.; Genhardt, M.; Sack, DA.; Skwerer, RG.; Wehr, TA. Seasonal affective disorder: relevance for treatment and research of bulimia. In: Pope, HG., editor. *Psychobiology of Bulimia*. American Psychiatric Press Inc; Washington, DC: 1987. p. 203-228.
- Rosenthal NE, Levendosky AA, Skwerer RG, Joseph-Vanderpool JR, Kelly KA, Hardin T, Kasper S, DellaBella P, Wehr TA. Effects of light treatment on core body temperature in seasonal affective disorder. *Biol Psychiatry*. 1990; 27:39–50. [PubMed: 2297550]
- Rosenthal NE, Sack DA, Gillin JC, Lewy AJ, Goodwin FK, Davenport Y, Mueller PS, Newsome DA, Wehr TA. Seasonal affective disorder. A description of the syndrome and preliminary findings with light therapy. *Arch Gen Psychiatry*. 1984a; 41:72–80. [PubMed: 6581756]

- Scott; Pellman. Living Without Electricity (People's Place Book No 9). Good Books; Intercourse, PA: 1999.
- Selvi Y, Aydin A, Atli A, Boysan M, Selvi F, Besiroglu L. Chronotype differences in suicidal behavior and impulsivity among suicide attempters. *Chronobiol Int*. 2011; 28:170–175. [PubMed: 21231879]
- Stiller JW, Postolache TT. Sleep-wake and other biological rhythms: functional neuroanatomy. *Clin Sports Med*. 2005; 24:205–235. [PubMed: 15892920]
- Szeinberg A, Borodkin K, Dagan Y. Melatonin treatment in adolescents with delayed sleep phase syndrome. *Clin Pediatr (Phila)*. 2006; 45:809–818. [PubMed: 17041168]
- Takahashi JS, Hong HK, Ko CH, McDearmon EL. The genetics of mammalian circadian order and disorder: implications for physiology and disease. *Nat Rev Genet*. 2008; 9:764–775. [PubMed: 18802415]
- Terman JS, Terman M, Lo ES, Cooper TB. Circadian time of morning light administration and therapeutic response in winter depression. *Arch Gen Psychiatry*. 2001; 58:69–75. [PubMed: 11146760]
- Terman M, Terman JS. Circadian rhythm phase advance with dawn simulation treatment for winter depression. *J Biol Rhythms*. 2010; 25:297–301. [PubMed: 20679499]
- Terman M, Terman JS, Ross DC. A controlled trial of timed bright light and negative air ionization for treatment of winter depression. *Arch Gen Psychiatry*. 1998; 55:875–882. [PubMed: 9783557]
- Thompson C, Childs PA, Martin NJ, Rodin I, Smythe PJ. Effects of morning phototherapy on circadian markers in seasonal affective disorder. *Br J Psychiatry*. 1997; 170:431–435. [PubMed: 9307692]
- Toh KL, Jones CR, He Y, Eide EJ, Hinz WA, Virshup DM, Ptacek LJ, Fu YH. An hPer2 phosphorylation site mutation in familial advanced sleep phase syndrome. *Science*. 2001; 291:1040–1043. [PubMed: 11232563]
- Tonetti L, Fabbri M, Martoni M, Natale V. Circadian type and mood seasonality in adolescents. *Psychiatry Clin Neurosci*. 2012; 66:157–159. [PubMed: 22300361]
- Voinescu BI, Szentagotai A, David D. Sleep disturbance, circadian preference and symptoms of adult attention deficit hyperactivity disorder (ADHD). *J Neural Transm*. 2012; 119:1195–1204. [PubMed: 22907800]
- Vollmer C, Michel U, Randler C. Outdoor light at night (LAN) is correlated with eveningness in adolescents. *Chronobiol Int*. 2012; 29:502–508. [PubMed: 22214237]
- Waddell MB, Jan JE, Bomben MM, Freeman RD, Rietveld WJ, Tai J, Hamilton D, Weiss MD. A randomized, placebo-controlled trial of controlled release melatonin treatment of delayed sleep phase syndrome and impaired sleep maintenance in children with neurodevelopmental disabilities. *J Pineal Res*. 2008; 44:57–64. [PubMed: 18078449]
- West KE, Jablonski MR, Warfield B, Cecil KS, James M, Ayers MA, Maida J, Bowen C, Sliney DH, Rollag MD, Hanifin JP, Brainard GC. Blue light from light-emitting diodes elicits a dose-dependent suppression of melatonin in humans. *J Appl Physiol*. 2011; 110:619–626. [PubMed: 21164152]
- Workman JL, Nelson RJ. Potential animal models of seasonal affective disorder. *Neurosci Biobehav Rev*. 2011; 35:669–679. [PubMed: 20800614]
- Young MA, Watel LG, Lahmeyer HW, Eastman CI. The temporal onset of individual symptoms in winter depression: differentiating underlying mechanisms. *J Affect Disord*. 1991; 22:191–197. [PubMed: 1939928]
- Zeitler JM, Dijk DJ, Kronauer R, Brown E, Czeisler C. Sensitivity of the human circadian pacemaker to nocturnal light: melatonin phase resetting and suppression. *J Physiol*. 2000; 526(Pt 3):695–702. [PubMed: 10922269]
- Zeitler JM, Khalsa SB, Boivin DB, Duffy JF, Shanahan TL, Kronauer RE, Czeisler CA. Temporal dynamics of late-night photic stimulation of the human circadian timing system. *Am J Physiol Regul Integr Comp Physiol*. 2005; 289:R839–844. [PubMed: 15890792]