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Seasonal affective disorder: Lighting research and Environmental psychology

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This review uses Seasonal Affective Disorder, a depression with a seasonal pattern, to illustrate why engineers, architects, and designers need to look beyond their disciplines and make use of the research output of environmental psychology. Studies of winter SAD in low latitude regions and SAD during summer have shown the need to move away from considering lighting in isolation towards a more holistic view of the environment including personal factors, as is done in environmental psychology.

1. Introduction

Studies contributing to knowledge of the prevalence and causes of Seasonal Affective Disorder (SAD), a depression with a seasonal pattern attributed mostly to the shorter winter photoperiod, show that there is more to SAD than light exposure since symptoms of seasonality or seasonal mood changes, have been identified in populations located fairly close to the equator.[1,2]

By using SAD as an example, the main objective of this paper is to show that if a deeper understanding of the role of light on psychological outcomes is desired, lighting research needs to expand its view to a more holistic view of the environment and its interaction with personal factors, as is done in environmental psychology.

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2. Seasonal affective disorder

Two characteristic syndromes of seasonal mood changes called SAD have been reported in the literature: recurrent depressions in autumn and winter with relapse in spring due to the increase in light with the corresponding drastic changes in the production of certain hormones;[3,4] and the opposite pattern, recurrent depressions in the summer. Individuals with milder symptoms, which neither meet the criteria for major affective disorder nor have sought treatment for their difficulties but nevertheless experience a mild dysfunction and vegetative changes similar to those found in SAD, have been classified in terms of subsyndromal SAD (sub-SAD). Patients with winter SAD are more likely to suffer from anergia, oversleeping, increased appetite, carbohydrate craving, and weight gain, whereas patients with summer SAD are more likely to suffer from agitation insomnia, decreased appetite, and weight loss.[5]

Rosenthal *et al.*[6] proposed the following operational criteria for the winter disorder: (1) A history of major affective disorder; (2) Development of such depressive episodes

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in the autumn or winter and remission by the following spring or summer in at least two consecutive years; (3) The absence of any other psychiatric disorder.

3. Hypotheses on the aetiology of SAD: the role of melatonin

Research on the aetiology of SAD has focussed on biological hypotheses, most notably that which postulates that the cause of SAD is related to the shorter winter photoperiod and the reduction in light exposure during autumn and winter.

Variation in environmental light is the primary stimulus that mediates entrainment in the mammalian circadian system. Cyclical changes, daily and seasonal, have been observed in biological activities of man and animals. A circadian rhythm is an endogenous rhythm that repeats with a period of about 24 h. Patterns of variation include activity, arousal, psychological performance, consumption of food and water, hepatic metabolism, urine volume and pH, blood pressure, heart rate, acid secretion in the gastrointestinal tract and cortisol secretion. The mechanisms by which light and other cues act to synchonise circadian oscillators is still a major goal of research.

Light incident on the retina produces a signal that progresses up the retinohypothalamic tract (RHT) to the suprachiasmatic nucleus (SCN) in the hypothalamus, which is believed to be the principal circadian pacemaker in mammals.

Cycles of light and darkness relayed by the retina entrain SCN neural activity, which in turn entrains the rhythmic production and secretion of melatonin from the pineal gland. Wurtman and his associates[7] put forth the melatonin theory of pineal function, which holds that the pineal body acts as a neuroendocrine transducer converting a neural input to hormonal output. In all vertebrate species studied to date, high levels of melatonin are secreted during the night and low levels are secreted during the day. In addition to entraining melatonin secretion from the pineal gland, light can have an acute suppressive effect on melatonin.[7–14]

In a prolonged situation of insufficient exposure to light, serotonin (one of the neuromediators essential in the regulation of mood, anxiety, impulse control, sleep, appetite and sexuality) might be excessively transformed into melatonin. Serotonin deficiency seems to be one of the main causes of mood disorders, from the simple sensation of mental fatigue — psychastenia — to the most important depressive state — nervous breakdown.[15] The seasonal pattern secretion of serotonin shows lowest levels in winter and spring and highest levels in summer and autumn.

Rusak *et al.*[16] listed several different hypotheses concerning links between light and SAD. The photon-counting hypothesis suggests that sufficient quanta of light are not available in short winter days to sustain a physiological process that is essential to preserving a normal mood state. The phase-shift hypothesis states that SAD patients have a circadian pacemaker abnormally entrained relative to external cycles and perhaps to other behavioural cycles. By contrast, the amplitude hypothesis suggests that the amplitude (rather than the phase) of critical circadian variables is reduced in SAD patients. According to the melatonin hypothesis, changes in the pattern of melatonin secretion (both increased and phase delayed or only phase delayed) as daylength shortens, may be responsible for the seasonal mood changes. However, a number of experimental studies have concluded that there are lower concentrations of melatonin at night in depressed patients.[17] In addition to its rhythm regulatory effect, melatonin has also been found to affect the immuno-defense system.[18] All of these hypotheses are not necessarily mutually exclusive.

4. Desynchronisation and light therapy

The internal clock can become phase shifted, or out of synchrony with the external world because of sleep deprivation, placement in constant conditions, exposure to light during the night hours, translatitudinal travel, or because of certain diseases such as seasonal affective disorder and delayed phase sleep disorder. This desynchronisation often provokes symptoms of discomfort.[4]

The existence of a relationship between the light–dark cycle on one hand and SAD symptomatology on the other has gained considerable support from the successful application of light therapy both in shift work and jet lag, as well as in SAD itself.

Since the inhibiting effect of light can only be obtained with fairly high levels, and since the timing and spectral composition of the light stimulation is of major importance, considerable research has been directed at determining the total dose of light (duration × illuminance) and time of day for the light treatment of SAD. Conditions for exposures to the eye are typically 2500 lx for 2–4 h or 10 000 lx for 30 min, at a distance of about 1 m from the light device to the face. Concerning the characteristics of effective light sources, several studies have investigated the action spectrum for SAD light therapy. On one hand, it seems that spectral quality is not as significant a parameter as illuminance; from this approach high illuminance from any traditional lamp will suffice.[16,17,19,20]

On the other hand, it is generally agreed that the peak sensitivity of the circadian and neuroendocrine system is in the blue–green portion of the visible spectrum.[21] A novel human opsin, melanopsin, that is expressed in cells of the mammalian inner retina, has been proposed as a circadian photoreceptor. Its unique inner retinal localisation suggests that it is not-involved in image formation but rather may mediate non-visual photoreceptive tasks, such as the regulation of circadian rhythms and the acute suppresion of pineal melatonin.[22] It is also possible that vitamin B_2-based cryptochromes are important for circadian photoreception.[23]

Since biological rhythms involve the entrainment (synchronisation) of external cues with an internal pacemaker, the time of day for the light treatment of SAD is not a minor detail. According to recent chronobiological models, the therapeutic potential of light is most efficient during the onset of daylight in the morning and the offset during the evening, in order to simulate a summer day.[19,24–26]

SAD is a complex disorder and culture also contributes to its aetiology. Kleimann and Good[27] emphasise that the effect of culture on mental illness is important to recognise in studies of aetiology, since being sad at times of the year is acceptable to northern Norwegians, the same type of sadness could be considered depression in an American perspective. Actually, what should be taken into account is the degree of impairment of the signs and symptoms in occupational or social functioning.

5. Forms of SAD not apparently linked to light

Since the most studied pattern is for depression to occur in the winter and a brighter mood (hypomania) to occur in the summer, several studies, which used different data collection methodologies, have been conducted to identify symptoms of seasonality, or seasonal variations in the symptoms most often quoted, namely: activity, well-being, sociability, appetite and sleep hours in populations located fairly close to the equator.

Community-based surveys on winter SAD prevalence showed percentages between 1.3% and 3% in Europe, 2% and 3% in Canada, 0.8% and 9.7% in North America and 0% and 0.9% in Asia.

During his clinical practice in the Punjab, India (27°–32° N), Gupta[28,29] observed the following three patterns of seasonal affective disorders: (1) hypomania or mania during the summer and depression in winter; (2) hypomania or mania in early winter and depression in middle and late winter and (3) severe depression in summer and hypomania or mania in winter.

Silverstone *et al.*[30] investigated if there exists a seasonal pattern of relapse in bipolar affective disorder (depressed and manic episodes), since the admission statistics for mania frequently show an increase during the summer. They studied two cohorts of bipolar patients, one in London, England (52° N) and the other in Dunedin, New Zealand (46° S). No consistent seasonal pattern of mania was detected in either centre but there was an autumn preponderance of depressive episodes in both centres.

Boyce and Parker[31] suggest by means of their study in Australia, that seasonal affective disorder associated with autumn or winter exists in the southern hemisphere and has a symptom pattern similar to that found in the northern hemisphere, but they also identified a group of subjects with a seasonal disorder associated with spring or summer.

Teng *et al.*[32] described a patient with bipolar affective disorder, who was living in a low-latitude area (Sao Paulo, 23° S), and this case raises the possibility of the occurrence in tropical latitudes of SAD, possibly with some features that differ from those described in higher latitudes.

Harris and Dawson-Hughes[33] conducted a 1-year longitudinal study of mood changes in 250 normal women, which showed that seasonal mood changes occur in normal middle-aged and older women living in New England (44° N). The mood scores appeared to be inversely related to day length, with 'worst' mood scores occurring in the fall and 'best' scores in spring or summer. Low mood scores were associated with fewer hours of sleep, and the vigour score was positively associated with physical activity. The thyroid hormone T4 was positively associated with higher depression levels in August through November, when depression levels were greatest, and also with greater vigour in February through May.

Consistent with most earlier findings, the findings of Hedge and Woodson[34] indicate that females experience greater seasonal changes in mood and behaviour than males, and older individuals experience less seasonal change than younger individuals. Seasonality scores were significantly higher in women between 21 and 40 years of age than in men and older women. A substantially higher percentage of women also has been found in cases that could be identified as winter or summer SAD. As with major depression, a higher seasonality score tends to occur in association with the reproductive years. The linkage of pre-menstrual syndrome to depression and the existence of *post partum* depression suggest that endocrine changes may be involved in the pathophysiology of depression.[5]

Küller *et al.*[35] conducted a large multinational research project carried out in Sweden, England, Saudi-Arabia, and Argentina during a 3-year-period on a total sample of 988 non-clinical individuals from basically healthy working populations. Taken together, the results lend considerable support to the assumption that the seasonal variations in day length may be the most important factor behind SAD symptoms. However, in the two countries close to the equator, temperature also seemed to be of considerable importance. The results show that the prevalence of sadness was common in Sweden and England, but less common and less severe in Argentina and Saudi Arabia.

Specifically, the study in northern Argentina (27° S)[36] showed that sadness was reported in a consistent way by half of the individuals in the sample, but in most cases

Table 1 Summary of cases

Location	Prevalence ratio (%)		Authors
	SAD	Sub-SAD	
Montgomery County, Maryland (39° N)	4.3 winter	13.5 winter	Kasper *et al.*[5]
Central Texas (30° N)	3.7 winter	17.4 winter	Hedge and Woodson.[34]
Nagoya, Japan (35° N)	0.9 winter		Ozaki *et al.*[37]
Japan (nation-wide survey)	0.87 winter		Sakamoto *et al.*[38]
Townsville, Northern Australia (19° S)	1.7 winter 9 summer		Morrisey *et al.*[39]

the symptoms were just noticeable. Still, 12% said they experienced clear or fairly strong sadness during part of the year. Altogether, six major seasonal patterns were identified, and among these, the winter variety was the most common (22%) followed by the summer variety (10%). A few cases also occurred during autumn (4%) and spring (2%).

Further findings of this study were a marked difference between the sexes, the females expressing much stronger sadness than the males; and the existence of an inverse relation between stress tolerance on one hand and the prevalence of SAD symptoms on the other, individuals of type A personality (characterised by signs of personal tension), on average reported their sadness to be three times as serious as did the individuals of type B personality (without these characteristics).

Table 1 summarises other winter and summer SAD and sub-SAD rates in percentages, as well as the authors of the study. Only those studies using the Seasonal Pattern Assessment Questionnaire (SPAQ) are listed.[5,34,37–39]

6. Discussion

All the investigations cited above make it likely that human seasonality may not be photoperiod-specific since excessive heat and humidity may influence the individuals living at low latitudes. Establishing whether temperature and humidity are significant in themselves or significant because they change behaviour so as to limit light exposure requires more specific studies.

From an environmental psychology point of view, seasonal variations in mood and behaviour might be regarded as adaptive responses to environmental changes which act as background stressors, and which in turn could trigger psychological symptoms.

Sensitivity to exposures and stress-factors vary between individuals and both personality attributes and lifestyles act as moderators of such an effect. Understanding of the stressors and vulnerability factors gives very important tools not only for understanding diseases but also for treating and preventing these.

Thus, concepts such as adaptation and personality type are likely to be of importance in the genesis of the disorder.

Although the study of the factors that influence the prevalence of SAD is generally not considered as typical of environmental psychology but rather an example of medical epidemiology, studies in the field of environmental psychology showed that light is important for avoiding tiredness and sadness in work environments.

7. Conclusion

Light probably constitutes the most conspicuous environmental variable related to human psychology, and Seasonal Affective Disorder (SAD) is a good example of light's effect. The effect of lighting on visibility has been studied for many years and is well understood. Visibility is determined by the physiological characteristics and capabilities of the human visual system.[40] However, there are several important aspects of the effect of lighting that depend on psychology rather than physiology. Among them are mood, motivation and behaviour. The problem with these responses is that they are influenced by many factors in addition to lighting. The greater is the separation between light as the stimulus and the desired response, the more likely it is that other factors are also important. The implication is that if we want to understand the effect of lighting conditions on psychological outcomes, we need to move away from considering lighting in isolation towards a more holistic view of the environment, as is done in environmental psychology.

Since the field of environmental psychology is interdisciplinary in nature, in which the study of the effects of all the different aspects of the environment are integrated and are interrelated with personal factors, and the reasons behind SAD still remain unclear, joint research work involving both lighting and environmental psychology will be a useful effort for interdisciplinarity activity. This may provide fruitful results in other areas of lighting where the effects of lighting on mood, motivation and behaviour are of interest to achieve efficient and healthy built environments.

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