Prophylactic treatment of seasonal affective disorder (SAD) by using light visors

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Prophylactic Treatment of Seasonal Affective Disorder (SAD) by Using Light Visors: Bright White or Infrared Light?

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Background: *Thirty-eight patients with SAD participated in a light visor study addressing two questions.*

1. *Can the development of a depressive episode be prevented by daily exposure to bright light started before symptom onset in early fall and continued throughout the winter?*
2. *Does the light have to be visible in order to have beneficial effects?*

Methods: *Three groups participated in the study: I (*n = *14) received bright white light (2500 lux); II, (*n = *15) received infrared light (0.18 lux); III (*n = *9, control group) did not receive any light treatment at all.*

Results: *Infrared light is just as effective as bright white light. Both are more effective than the control condition.*

Conclusions: *Light visors can be effectively used to prevent the development of SAD. The fact that exposure to infrared light was as effective as exposure to bright white light questions the specific role of visible light in the treatment of SAD.* Biol Psychiatry 1999;46:239–246 © *1999 Society of Biological Psychiatry*

Key Words: Seasonal affective disorder, prophylactic treatment, light treatment, light visor

Introduction

Seasonal affective disorder (SAD, winter type) is a syndrome recurring almost every year, with symptoms in autumn and winter, followed by a complete recovery every spring and summer (Rosenthal et al 1984). Light therapy has been shown to be a very effective treatment (Terman et al 1989; Tam and Lam 1995). Because of the almost predictable course of the syndrome, research was performed to find a way to prevent the winter symptoms. Light exposure at an early stage of a depressive episode can prevent the emerging winter depression (Meesters et al 1993). Terman et al (1994) were unable to replicate these findings but found that a subsequent episode of winter depression was postponed by light therapy administered after the first signs of a depressive episode. Light treatment administered at a time before the winter season (when the patients were free of symptoms) was ineffective, however (Meesters et al 1994). This study presents the results of a design where patients used light visors at home in the winter season. This is in line with our earlier studies on light treatment and the possible prevention of winter depression.

Light visors are portable head-mounted devices, which have been shown to be successful in the treatment of winter depression (McIntyre et al 1990; Ravaris et al 1994; Rosenthal et al 1993; Joffe et al 1993; Stewart et al 1990; Levitt et al 1994, 1996; Teicher et al 1995). The reported response rates in these studies ranged from 36% to 58%. Stewart et al (1990) and Levitt et al (1996) did not find any differences between the treatment responses to a light visor and a conventional light box. When used as a maintenance therapy after successful intervention by means of light boxes, light visors induced the same response level as light boxes (Clark et al 1996).

The mechanisms underlying the effects of light treatment in SAD are still unclear. The response to light treatment may be a placebo effect (Eastman 1990). Light visor treatment has been shown to be effective for a variety of bright white light intensities (Joffe et al 1993; Rosenthal et al 1993; Levitt et al 1994) and colors (Teicher et al 1995). Levitt et al (1994) used red light (660 nm) from a light-emitting diode in a head-mounted device and did not find any differences between the therapeutic responses to light with intensities of 4106 lux and 96 lux. In the study of Teicher et al (1995), it was found that the response to low-intensity red light (>600 nm) was at least equal to the response to bright white light. In extrapolation of those findings, we raised the question of whether it is necessary for the light to be *visible* to achieve beneficial

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effects. Exposure to infrared light (>700 nm) might also be effective.

In view of these considerations, a light visor study was designed addressing the following questions.

1. Can the development of depressive episodes be prevented by daily exposure to bright light *initiated before* symptom onset in the early fall and continued throughout the winter season?
2. Does the light have to be visible to have beneficial effects?

Methods and Materials

Fifty SAD out-patients gave their consent to take part in the study (30 in the winter season of 1993-94; 20 in the winter of 1994-95). All were free of drugs and diagnosed as suffering from seasonal affective disorder according to the criteria of Rosenthal and co-workers (1984), and seasonal pattern according to the DSM-III-R (APA, 1987) and suffered from regular annual depressions. The time of consent was September and the study started in October. At that time, four patients had already developed a depression and were unable to take part in the experiment for that reason. The remaining 46 patients were assigned to one of three conditions.

Condition 1: Exposure to bright white visor light (BL; n = 14; 2 men, mean age 41.0 yrs ± 12.7; 12 women, mean age 39.5 yrs ± 9.3)

Condition 2: Exposure to infrared light (IR) by means of a light visor equipped with a Kodak Wratten filter (type 89b, 720 nm) (n = 15; 5 men, mean age 35.4 yrs ± 6.9; 10 women, mean age 36.6 yrs, ± 4.9)

Condition 3: No light exposure (CON); no light visor provided (n = 9; 4 men, mean age 47.5 yrs ± 7.0; 5 women, mean age 39.4 yrs ± 8.0)

Figure 1 shows the spectral power distribution of the two light sources.

The first winter, equal numbers of patients were randomly assigned to all three conditions. Because of the limited number of participants we were able to recruit the second winter, we decided to assign twice as many patients to each of the light conditions as to the control condition. This assignment was also random.

All patients were known SAD patients who had had successful conventional light treatments in previous winter seasons. Evidently, the patients in the untreated control group ran a considerable risk of becoming depressed. This group, therefore, represented a kind of waiting-list control group. From previous studies, it is known that not every SAD patient becomes depressed every year (Thompson, 1989; Meesters et al 1993). It is therefore important to collect data concerning this type of a waiting-list control group. Statistically, the subjects of the three groups did not differ in age, gender, or season of participation (ANOVA).

Eight subjects dropped out during the experiment for the following reasons: one failed to wear the light visor; one started

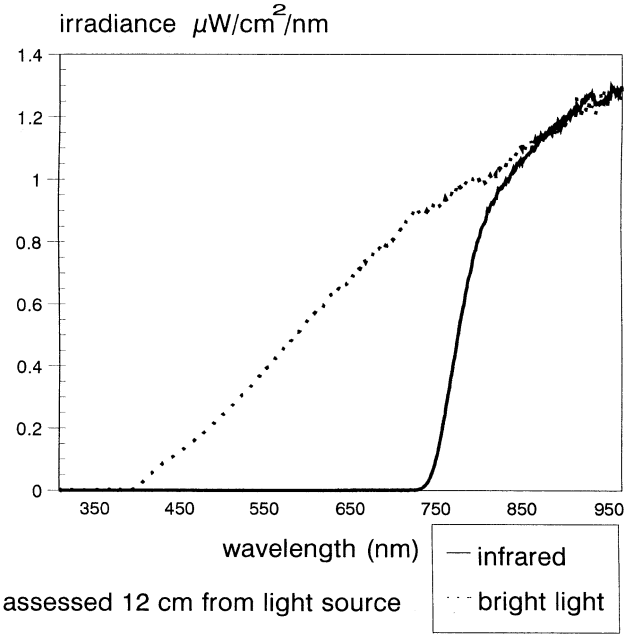

Figure 1. The spectral power distribution of bright white light and infrared light from a light visor.

using medication; one patient in the control condition was treated with light therapy at her own emphatic request (light box) after reaching a BDI score ≥13 in 1 week instead of 2 weeks; another five patients stopped participating because of reasons unrelated to their illness, such as a lack of motivation to keep scoring self-rating scales when in a healthy mental state, moving to a new home, etc. In the bright light condition, four subjects dropped out, in the infrared condition, three, and one subject in the control condition. We do not have systematic information on the drop-outs for the rest of the season.

The light visors were manufactured by Bio Brite Inc. (Bethesda, MD, USA). They contained two krypton incandescent bulbs powered by a rechargeable battery. Subjects used them 30 min daily (except on Saturdays and Sundays) between 6:00 and 9:00 AM.

This study was a field study. Light treatment was part of every day life. Participants were asked to choose their own fixed treatment time in their daily routine. They registered this time during the season.

Mood was assessed weekly by means of the Beck Depression Inventory (BDI, 21-item version, Beck et al, 1961; 1979), and a translated version of the SIGH-SAD-SR (29-item version, Williams et al 1992). Patients reaching a BDI score of ≥13 in 2 consecutive weeks were considered to have developed a depressive episode. If patients reached a BDI score of ≥22, they were considered to be severely depressed, and left the study at that moment. They were offered light treatment in the clinic. As statistical procedure, the Kaplan Meier Survival Analysis was used (Kaplan and Meier 1958).

In our first studies we used the BDI (Beck et al 1961; 1979) to assess the severity of depression. Terman and co-workers (1994) compared the scores of the BDI with scores of the SIGH-SAD-SR (Williams et al 1992) and found some differences.

Patients with relatively mild depression scores according to the BDI appeared to be more severely depressed on the basis of the SIGH-SAD-SR scores. Data of the present study allow comparison of the scores of the BDI and the SIGH-SAD-SR. Following Terman and co-workers (1994), we assumed that a SIGH-SAD-SR score of ≥20 is equivalent to a BDI score of ≥13 and a SIGH-SAD-SR score of ≥40 is equivalent to a BDI score of ≥22 (severe depression).

Results

BDI

Thirty-six percent (5 out of 14) of the patients in the bright light condition developed a depression (one of them severe), against 7% (1 out of 15) in the infrared condition (severe) and 78% (7 out of 9) in the control condition (6 of them severe). Figure 2A shows the average BDI scores per condition.

According to a Kaplan Meier Survival Analysis, the results in the infrared light condition were significantly better than those in the bright white light condition (Breslow stat.: 4.38; df = 1; $p = 0.04$). Similarly, the results in the IR condition were better than the results in the control condition (Breslow stat.: 17.81; df = 1; $p = 0.000$). Finally, there was a statistically significant difference between the results of the bright white light condition and the results of the control condition in favor of the light condition (Breslow stat.: 8.85; df = 1; $p = 0.03$) (Figure 3A).

In the IR condition, only one subject became depressed. Therefore, it was not possible to perform multiple pairwise comparisons. No significant correlations (Spearman) were found between age or gender on the one hand, and the outcome measures on the other.

SIGH-SAD-SR

When we used the SIGH-SAD-SR criterion, the results were slightly different. Forty-three percent of the patients (6 out of 14) in the bright light condition became depressed (one of them severe), 33% (5 out of 15) in the infrared condition (one of them severe) and 67% (6 out of 9) in the control condition (3 severe) (Figure 2B).

Kaplan Meier Survival Analysis showed no difference between the results of the two light conditions. The results in the infrared condition were significantly better than those in the control condition (Breslow stat.: 5.55; df = 1; $p = 0.02$). The results of the bright white light condition showed a tendency to be better than those in the control condition (Breslow stat.: 3.21; df = 1; $p = 0.07$) (Figure 3B).

BDI Versus SIGH-SAD-SR

Six patients reached the SIGH-SAD-SR criterion but failed to reach the BDI criterion for recurrence of a depressive episode. Two patients who reached the BDI criterion did not reach the SIGH-SAD-SR criterion. The larger number of patients who reached the SIGH-SAD-SR

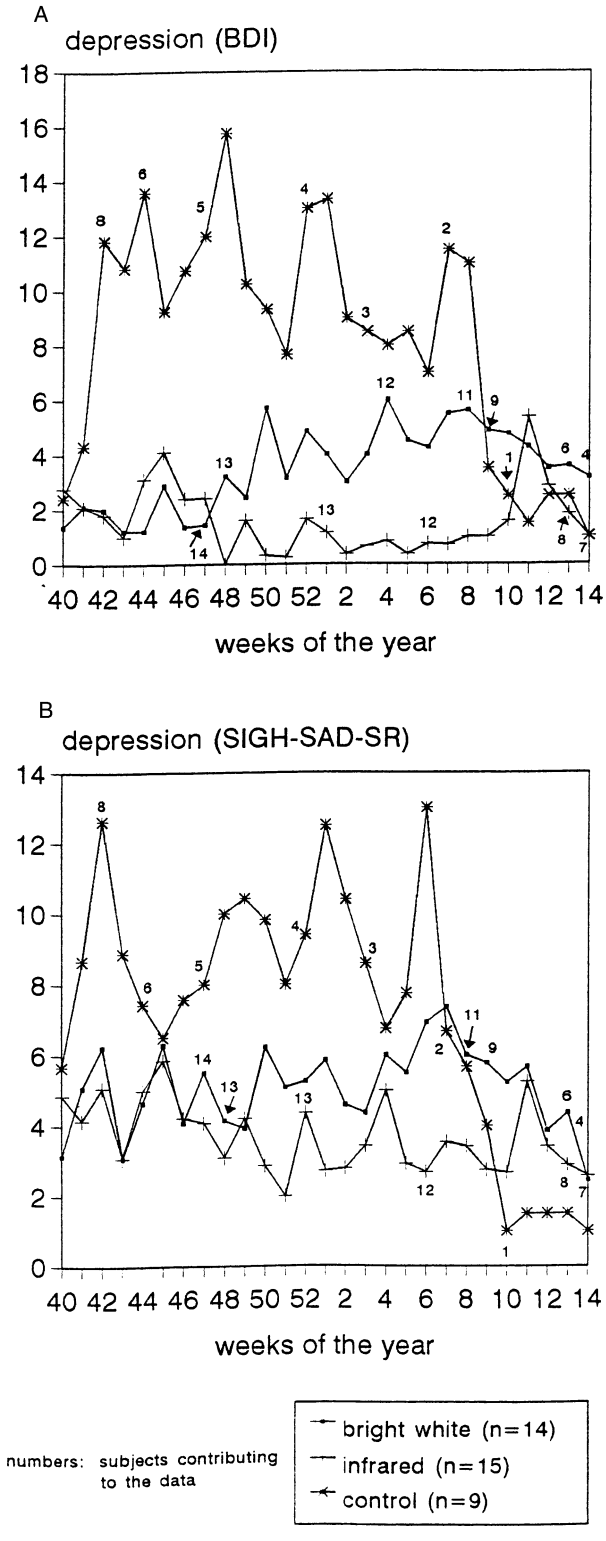

Figure 2. The course of mood during the winter season as assessed by means of the BDI (A) and the SIGH-SAD-SR (B).

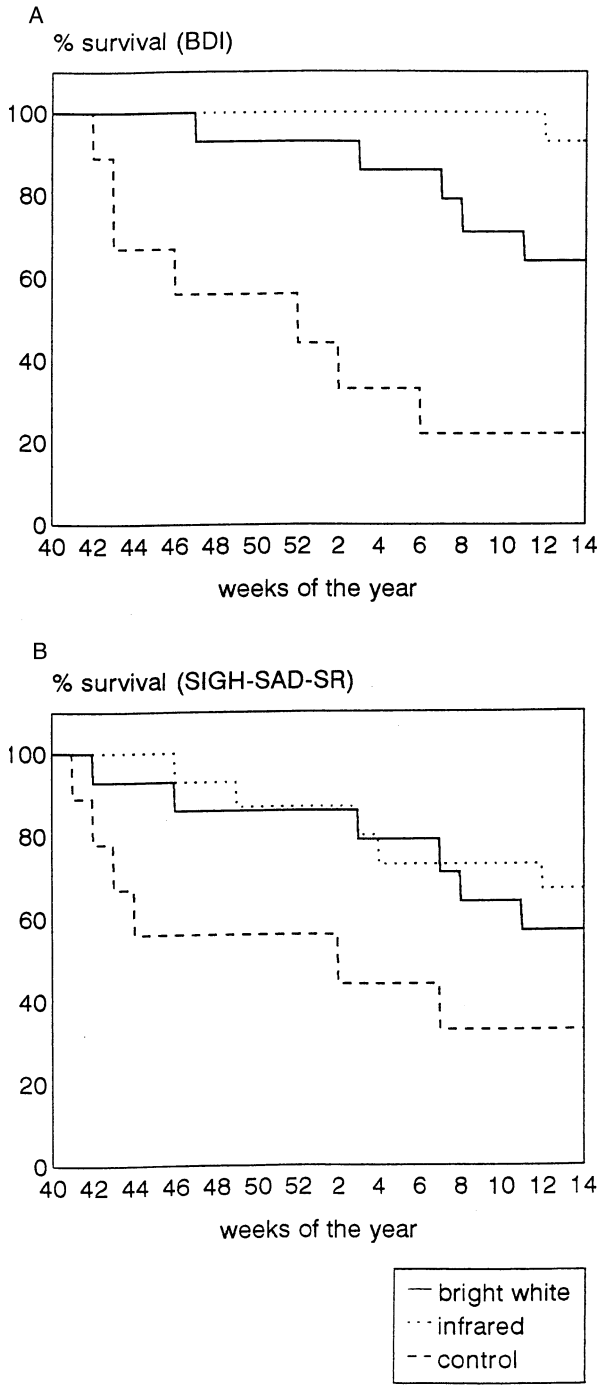

Figure 3. The survival curves based on the BDI criterion (A) and the SIGH-SAD-SR criterion (B).

criterion is mainly due to their scores on the atypical symptom items in that questionnaire. These symptoms are not assessed by means of the BDI. Thirteen subjects in this study reached our BDI criterion for depression. Ten of them (77%) had a score of ≥5 on the atypical score section of the SIGH-SAD-SR.

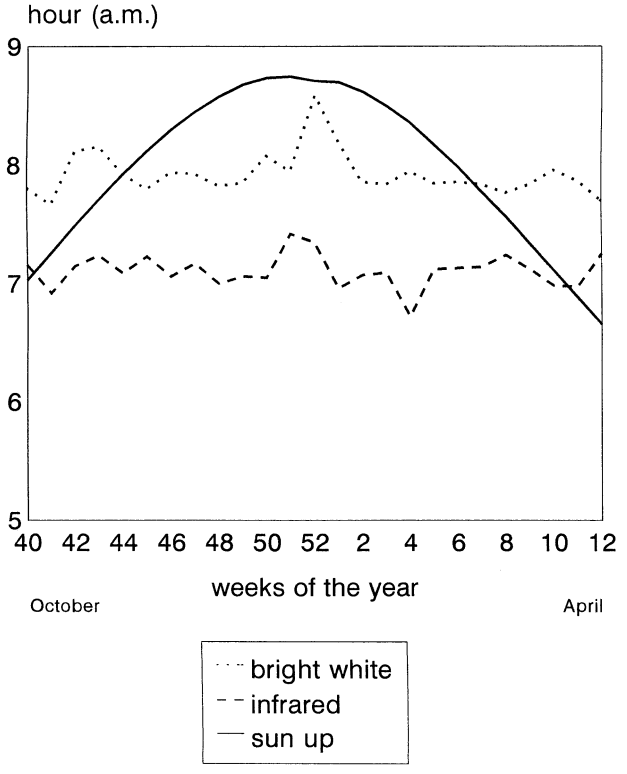

Figure 4. The mean time schedule, compared to sun-up times, of the bright white and infrared light conditions with patients wearing light visors during the winter season.

Timing

At the end of the two winter seasons it became clear that there was a difference between the two groups in the times of day they had used the light visor. The BL group started light exposure at a mean time of 7:55 AM, the IR group at 7:10 AM. This difference is statistically significant (two-tailed t test: 2.64, $p = 0.014$; see Figure 4).

Subjects who became depressed according to the BDI criterion were offered light treatment by means of light boxes in the out-patient clinic of the hospital. In some subjects, the depression seemed to have come about by events unrelated to the seasons. The father of one of the subjects in the bright light condition died that winter season, while at the same time her own business was going into bankruptcy. A subject in the infrared condition became depressed after his wife suddenly left him. These kind of life events cannot be avoided in a field study. On the other hand, it is unlikely that the change of mood induced by these events can be treated with light. From the other 11 subjects who became depressed, 6 received light treatment and responded successfully. These 6 subjects all participated in the waiting-list control group. The other 5 subjects did not accept the offer of light treatment and stayed depressed for 2, 2, 2, 4 and 5 weeks (with BDI scores ranging from 13 to 17), respectively.

Discussion

Prophylaxis

This study demonstrates that SAD patients wearing a light-emitting visor in winter develop fewer symptoms than waiting-list control subjects. We were unable to settle the question of whether these results should be interpreted in terms of prevention of symptoms, or maintenance therapy. We do not see how we can distinguish these interpretations, and have pragmatically chosen the term prophylactic treatment for our approach.

A light visor emitting infrared light seems to provide at least as much protection as a light visor emitting bright white light. This finding is in line with the data of Teicher and colleagues (1995), who failed to find a statistically significant difference between the response to a light visor with white light (600 lux) and a light visor with dim red light ($>$ 600 nm, 30 lux). The fact that both light visor conditions are more effective than the control condition, leads to the conclusion that light visor treatment can be used as a prophylactic intervention for SAD patients.

The possibility of using light treatment as a prophylactic tool was also reported recently by Partonen and Lönnqvist (1996) and Clark and co-workers (1996). Although the course of the symptoms is significantly better in the treatment conditions than in the control condition, this does not mean that the present design provides optimal prophylaxis. Not all patients remained symptom-free during the winter season. In the bright light condition, according to the BDI scores, 36% of the participants became depressed and in the IR condition 7%. According to the SIGH-SAD-SR, even more participants reached the criterion of depression (BL 43% and IR 33%). In both conditions, one participant became severely depressed. Our data are in line with those found in a comparable study in which 28% of the subjects became depressed in spite of prophylactic exposure to light (Kjellman et al 1997).

The relatively high number of depressive episodes occurring in the light conditions is unexpected. A 5-day light-box treatment applied at the first signs of a depressive episode was previously shown to prevent a severe depressive episode during the remaining part of the winter season (Meesters et al 1993). Since the present light visor treatment started before symptom onset and so covered the phase of an emerging depression, an equal preventive potential would be expected. Furthermore, many light-box studies have demonstrated that an average treatment period of 4 to 5 days usually suffices to induce a substantial therapeutic response (Meesters et al 1995). Following this line of reasoning, the continued application of the light visor should have been sufficient to suppress the emerging depression in all patients. Apparently, there are differences in efficiency between our previous light-box treatment and the present light visor treatment. One of the differences is the fact that in our earlier studies light boxes were applied in the out-patient clinic whereas the light visors in this study were used at home. This might be an important aspect. Obviously, patients treated clinically by an expert receive more attention and perceive more security.

Spectral Properties of Light

In our two light visor conditions the light spectrum differs ($>$400 nm versus $>$720 nm), while the therapeutic responses do not. The SAD literature on the therapeutic significance of the spectral properties of light is confusing. We list the studies in this area. Teicher et al (1995) found no differences between the results of white and dim red light visor treatment, but Brainard and co-workers (1990), using light boxes, reported a superiority of white light over blue or red light in a study comparing the effects of different wavelengths. Also using light boxes, Oren et al (1991) found green light to be superior to red light, while Rice and al (1991) concluded that green light was less effective than full spectrum light. No difference in response was found to treatment with cool white light and broad spectrum fluorescent light of light boxes (Bielski et al 1992). Lam and colleagues (1992) observed that the ultraviolet part of the spectrum did not increase the antidepressant response to light treatment using light boxes. Avery and co-workers (1994) reported the superiority of white over red light in a study on the effects of dawn simulation. Obviously, the data on the spectral sensitivity of SAD patients are inconsistent. Theoretically, it is possible that each kind of light source used has its own optimal spectral composition, so we cannot compare the results of different wavelengths emitted by different light sources. Since Stewart and colleagues (1990) and Levitt et al (1996) found no difference in therapeutic response when comparing the effects of exposure to light of light boxes with the effects of exposure to the light of light visors, we do not believe that that is very plausible.

The finding that the effects of the two light treatment conditions did not differ, raises some doubts about the assumption that the perception of light plays a significant role in the therapeutic mechanism that is responsible for the results. Can we expect IR light to play any role at all? Inoué and Kabaya (1989) reviewed the effects of far infrared radiation (4 to 16 μm) and concluded that these rays are "biologically active" in various ways. Almost every light fixture produces light with an infrared component. So, our data indicate that, *if* light is crucial to the response, it must be that component which is crucial. However, infrared light is beyond the visible range of the spectrum. The 720 nm filter in our light visor still

transmitted some visible light. However, its visibility was virtually negligible (0.18 lux). The conclusion of this study might therefore be that the *perception* of light does not play a role in the therapeutic mechanism. Infrared might be effective through pathways other than those involved in perception.

Circadian Mechanisms

The effect of low-intensity red light on the human circadian pacemaker has recently been demonstrated by Zeitzer et al (1995). Exposure to nocturnal dim red light creates a phase advance comparable to the phase advance after exposure to white light. This finding would be consistent with the possibility that the circadian pacemaker plays a role in the mechanism underlying the effects of light therapy. But even when the effects are induced by invisible light, this kind of interpretation would be inconsistent with other studies that show that therapeutic effects of light are unrelated to the timing of light exposure (Wirz-Justice et al 1993; Meesters et al 1995). Curiously enough, though, the participants in the IR condition selected the time of light exposure about 1 hour earlier than the participants in the bright light condition (Figure 4). At that time, the circadian pacemaker is thought to respond to light pulses with a larger phase advance than it does 1 hour later (Jewett et al 1991; Minors et al 1991). So, if, in fact, phase shifts of the circadian pacemaker are involved in the therapeutic response, this difference in time selection might explain why the response to IR light is slightly superior to the response to bright white light. However, it should be noted that the smallest light intensity for which phase responses of the pacemaker has been demonstrated in humans is 180 lux (Boivin et al 1996) while our IR light contained only 0.18 lux. It should also be remarked that, although phase shifts are seen as a marker of the effect of light on the circadian system, Amir and Stewart (1996) showed that phase shifts can also be induced by a conditioned stimulus. Obviously, the role of the circadian system is far from clear.

In addition, it is not clear what part of the visual system receives the input signal to the circadian pacemaker. In animal studies the presence of photopigments in the retina was manipulated. In genetically manipulated mice, which only had cone cells within a restricted area of the retina, and no rod cells at all, there still was a normal circadian response to light (Garcia-Fernandez et al 1995; Argamaso et al 1995). These cone cells degenerate with aging. However, circadian responses to light still appeared in aged mice with retinal degeneration (Provencio et al 1994). Whether, and in what way, the conclusions of this experimental approach in mice can be generalized to humans is unclear.

Ise et al (1987) described that blood flow can be stimulated by means of far infrared radiation (4 to 16 μm). Although far infrared differs from infrared light, the present results are interesting when considered together with the recent hypothesis of Oren (1996), who states that blood possibly plays a role as messenger of the effects of light on the brain. The infrared light in the dusk and dawn periods are thought to function as a kind of trigger for a circadian switch. Our data would seem to fit with this hypothesis that IR light can influence the circadian system and possibly the course of mood. Taken together, the considerations mentioned demonstrate that little is known about the circadian mechanism involved in the effects of light treatment.

Other Mechanisms

Other mechanisms may explain the beneficial treatment effects in SAD patients. Geerts and co-workers (1995) found evidence for the assumption that behavioral processes during the interaction between patients and interviewers measured prior to treatment may play a role. Bouhuys et al (1994) found that some cognitions as assessed in the autumn are involved in the timing of a new SAD episode. Expectations and cognitions may also have played a role in the present study. Unfortunately, we did not assess the subjects' expectations about the therapeutic potential of the light fixtures at the beginning of the study, and we did not assess cognitions about the significance of light and darkness for their mental well-being. Wearing a light visor (during the winter for 5 days/week) implies that patients are actively engaged in protecting themselves from depression. Non-SAD depressed patients benefit from self-help techniques, where they also take an active part in their treatment (Gould and Clum 1993). Therefore, patients' active involvement with concomitant cognitions and expectations, rather than the exposure to light, may explain why the two light visor treatments are superior to the control condition.

It is still possible that placebo effects entirely account for the therapeutic outcome. Compared to a light-box, a light visor looks like an "ingenious" fixture, and the infrared light makes it even more special. These effects might account for the results (Eastman 1990). This line of reasoning is consistent with the fact that until now no dose-response relationship has been observed in light visor studies (Joffe et al 1993; Teicher et al 1995; Rosenthal et al 1993; Levitt et al 1994). In an experiment using an inactivated ion-generator to treat SAD patients, Eastman and co-workers (1992) reported positive results, indicating that placebo treatments are effective in SAD and that the results are similar to those of light treatment. In a study comparing the results of exposure to a light box and a

head-mounted light fixture, both in a version with visible light and a version without any light, Levitt et al (1996) did not find a statistically significant difference between the four conditions. Recently, Eastman and colleagues (1996) claimed that a 4-week period of light treatment is more effective than a placebo. Yet, the groups in that study only differed with respect to the numbers of patients who reached a remittance criterion, but not with respect to the final treatment outcome after 4 weeks. Richter et al (1992) found that the effects of real morning light were not different from those of imaginary morning light immediately after the treatment. However, 10 days after treatment, real light turned out to be superior. Considering this area of research makes it clear that the issue of the placebo effects of light treatment has not been settled yet.

A final topic to be discussed is the comparison of BDI criterion for depression and the SIGH-SAD-SR criterion. In this study, 17 out of 38 subjects became depressed according to the SIGH-SAD-SR criterion and 13 according to the BDI criterion. For a psychometric comparison of the two questionnaires, the sample size is too small. Nevertheless, our data are consistent with the statement of Terman et al (1994) that the BDI is less sensitive in detecting a depressive episode in SAD patients than the SIGH-SAD-SR.

In conclusion, the present study demonstrates that visible light is not a prerequisite for the therapeutic response of SAD patients to light treatment. Whether IR light is a critical therapeutic factor remains to be investigated.

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