

Treatment of Seasonal Affective Disorder With Green Light and Red Light

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Objective: This study sought to determine whether an equal photon density of green light is superior to red light in treating seasonal affective disorder. **Method:** After recruitment through the media, 20 outpatients with seasonal affective disorder participated in a balanced-order crossover trial of 1 week of green light therapy compared with 1 week of red light therapy. Each treatment consisted of 2 hours of daily light treatment at home in the early morning. Ultraviolet light was excluded from both treatment conditions. The photon densities of the two treatments (2.3×10^{15} photons/sec per cm^2) were similar to those used in previous studies of therapy with 2500-lux white light. Fourteen patients completed the study. At least 1 week separated each treatment period to allow time for relapse. Effectiveness of treatment was assessed by analysis of variance of changes in ratings on the Hamilton Rating Scale for Depression. **Results:** Although patients' expectations of the two treatments were similar, green light induced greater antidepressant effects than red light. A Sequence by Color interaction was also demonstrated. **Conclusions:** Green light provides a treatment effect superior to that of red light and similar to that seen in previous studies with white light. These results are consistent with the hypothesis that retinal photoreceptors mediate the antidepressant response in seasonal affective disorder. Identifying optimal wavelengths for light treatment is important in optimizing phototherapy efficacy.

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Seasonal affective disorder (1) may be treated with white light (2). A recent study (3) suggested that white light is more therapeutic for this disorder than red or blue light. No trial, however, has established whether a specific wavelength band can treat the disorder effectively.

We conducted a crossover study of the antidepressant effects of green versus red light in seasonal affective disorder. We chose green because retinal photoreceptors are more sensitive to green wavelengths than to any other band of visible light (4), and we chose red

because of its previous use as a plausible placebo for depressed patients (3, 5).

METHOD

The subjects were recruited through the media. Criteria for entry into the study were 1) a diagnosis of seasonal affective disorder (1), 2) a score of at least 13 on the 21-item Hamilton Rating Scale for Depression, 3) no phototherapy for 10 days before the study, and 4) no previous experience of therapy with green or red light. All subjects gave informed consent. They kept their sleep schedules and medication regimens, if any, constant for 2 weeks before the study and throughout the trials.

In winter, during different 7-day periods, these depressed patients were exposed in their homes to different daily 2-hour treatments with colored light between 5:30 a.m. and 9:00 a.m. The treatments were administered in a balanced, randomized crossover design with at least 7 days between treatment periods. Raters who were blind to the order of the treatments evaluated patients weekly with a structured interview

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TABLE 1. Scores on the 21-Item Hamilton Rating Scale for Depression of 14 Patients With Seasonal Affective Disorder Treated With Green and Red Light

Condition/ Patient	Hamilton Depression Score			
	Green Light		Red Light	
	Baseline	After 1 Week	Baseline	After 1 Week
Green light first				
1	28	16	14	4
2	17	1	12	12
3	24	13	14	21
4	18	6	18	19
5	13	2	12	3
6	18	12	12	18
7	27	15	15	6
Group				
Mean	21	9	14	12
SD	6	6	2	8
Red light first				
8	13	12	21	15
9	18	5	18	4
10	12	21	13	21
11	29	4	26	16
12	13	0	18	4
13	19	7	23	3
14	12	12	17	18
Group				
Mean	17	9	19	12
SD	6	7	4	8
Total				
Mean	19	9	17	12
SD	6	6	4	7

that included the 21-item Hamilton depression scale and an atypical symptom subscale (6). Patients' Hamilton scale scores were required to be 12 or higher before the second treatment—lower than required for the initial treatment, since depression frequently takes more than 1 week to relapse to pretreatment levels. If a patient's Hamilton score was less than 12 after 1 week, additional weeks were allowed for relapse.

In the two lighting conditions we used equal quanta (2.3×10^{15} photons/sec per cm^2) of red or green light—similar to those used in previous studies of therapy with 2500-lux white light (1–3, 7). All lamps (fluorescent 40-W red and fluorescent 40-W green) were “burned in” and housed in portable fixtures with clear pyramidal diffusers and ultraviolet and gelatin filters. The red and green light units emitted half-peak bandwidths of 615–685 nm and 505–555 nm, respectively. To balance photon density, patients sat 30 inches from a unit containing eight green bulbs in one condition and 20 inches from a unit containing 16 red bulbs in the other.

Patients were not informed about the color of light they would receive each week until each treatment condition began. After experiencing the treatment condition briefly, each patient completed an expectation assessment form (8). We assessed color vision weekly with a Nagel anomaloscope, the Farnsworth-Munsell 100-hue test, or both.

We examined changes in mood by means of analysis

of variance (ANOVA) with one grouping factor (sequence) and one repeated measure (color), and we compared changes in scores on the structured interview by means of *t* tests. We evaluated expectations with the Wilcoxon signed-ranks test and Spearman rank-order correlations.

RESULTS

Ten women and four men completed the experiment. Ten of these patients met criteria for unipolar depression, and four met criteria for bipolar II depression. No patient showed evidence of abnormal color vision. Seven patients were assigned to each color treatment first. Six other patients did not complete the study because of noncompliance, medical illness, or failure to relapse after the first treatment condition.

The ANOVA of Hamilton depression scores showed a color effect ($F=6.2$, $df=1, 12$, $p<0.05$) and a Sequence by Color interaction ($F=6.2$, $df=1, 12$, $p<0.05$) (table 1). The interaction occurred because patients treated with red light first had equal improvements in depression scores in both conditions (8 ± 11 with green and 8 ± 10 with red), whereas patients treated with green light first had a much larger improvement with green light (11 ± 3) than with red light (2 ± 7). Hamilton depression ratings before the two treatments were not significantly different. Using *t* tests, we found that changes in Hamilton score were significant for the green light condition only (green light, $t=4.5$, $df=13$, Bonferroni $p<0.005$; red light, $t=2.1$, $df=13$, Bonferroni $p>0.10$, $p=0.58$). The mean \pm SD change in atypical symptom score with green light was 6 ± 7 points ($t=3.5$, $df=13$, Bonferroni $p<0.05$), and the change with red light was 7 ± 7 points ($t=3.5$, $df=13$, Bonferroni $p<0.05$). The ANOVA for atypical symptoms showed no sequence, color, or interaction differences.

Expectations of response in both conditions were similar and largely positive. There was no correlation between expectations of improvement and changes in Hamilton depression score in either condition.

DISCUSSION

The antidepressant effect of green light was superior to that of red light. The magnitudes of change in Hamilton depression score with green and red light resemble those observed in previous studies in which an active form of phototherapy was compared with an inactive one (2).

Since ultraviolet radiation was screened out from both the red and the green light sources, this study suggests that ultraviolet radiation is not critical to phototherapy in seasonal affective disorder. Since ultraviolet radiation has been associated with adverse effects, it is important for clinicians to know that ultraviolet is probably unnecessary for the antidepressant effects of

phototherapy. We cannot rule out the possibility, however, that phototherapy for seasonal affective disorder might be more effective with a certain amount of ultraviolet radiation. Similarly, the failure of red light as an antidepressant in this study should not be viewed as proving that it is ineffective, but only that it was ineffective in this paradigm.

The effectiveness of green light is consistent with the hypothesis that retinal photoreceptors mediate the antidepressant response in seasonal affective disorder. In view of these experimental results, it seems logical to focus the search for biological mechanisms of phototherapy on processes involving photoreceptors.

We also explored the relation between expectations of and responses to phototherapy. Expectations of the two types of phototherapy poorly predicted patients' responses to treatment. This suggests that expectations did not account for most of the therapeutic effect of green light that we saw in this study.

A Sequence by Condition interaction has been found in several studies of seasonal affective disorder. One interpretation of the interaction we found in our study is that the placebo effect of red light was almost as powerful as green light in the first treatment condition.

Several properties of phototherapy that are critical for its therapeutic effect have been identified. Intensity (1) and duration (2) appear to be important. Early

morning may be the most effective time for treatment (2, 7), although this hypothesis is controversial. In this study we addressed wavelength. It now seems that ultraviolet-free green light will provide a treatment effect similar to that seen with white light in earlier studies.

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