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Research report

Prediction of acute and late responses to light therapy from vocal (pitch) and self-rated activation in seasonal affective disorder

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Abstract

It was hypothesized that pre-treatment activation plays a role in the response to light therapy in Seasonal Affective Disorder (SAD). In 55 SAD patients (DSMIII-R) energetic and tense activation was assessed before light therapy via self-rating (AD-ACL) and voice sound characteristics (mean pitch and variation in pitch). These variables were studied in relation to the "acute" response to 4 days of light therapy (30 min. 10 000 lux) and to a "late" response (11 (10) days after light therapy had stopped). Acute response was defined as the percent change in 3 times daily self-rated depressed mood (AMS) with respect to the average of 4 baseline days. "Late" response was defined as the percent change in HRSD or AMS scores between baseline and 11 (10) days after light therapy. It was found that patients having high pitched voices with small variation in this pitch benefitted more from light therapy than the patients with low pitch and large variation in pitch levels. This effect was only significant after the first day of light exposure. No other significant relations were found between baseline activation and acute or late responses to light therapy. Hence, light therapy seems to give extra comfort in "tense" patients, who become rapid responders to light therapy. © 1997 Elsevier Science B.V.

Keywords: SAD; Activation; Fundamental frequency; Prediction; Response; Light therapy

1. Introduction

Seasonal affective disorder (SAD) is characterized by recurring periods of depressive symptoms in autumn or winter and remission in summer (Rosenthal et al., 1984). Exposure to bright artificial light results in remission in about 30–70% of the

patients (Terman et al., 1989; Meesters et al., 1993; Thalén et al., 1995). The pathogenesis of SAD and the mechanism of action of the response to light therapy are not well understood. Until now the main focus of the investigations has been on the level of "biological" theories, concerning melatonin secretion, circadian rhythms, neurotransmission function etc. (Blehar and Lewy, 1990; Rosenthal and Wehr, 1992). However, some studies indicate that psychological factors also play a role in the response to light treatment (Lilie et al., 1990; Brown, 1990;

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Richter et al., 1992; Eastman et al., 1992; Geerts et al., 1995).

Study of the relationship between pre-treatment characteristics of SAD patients and the subsequent response may reveal underlying (causal) processes. In non-seasonal depression it has been found that the degree of activation has predictive value with respect to outcome (Kupfer and Spiker, 1981; Avery and Silverman, 1984; Parker et al., 1992). In SAD little attention has been paid to the role of pre-treatment activation for the response to light therapy. Meesters et al. (1993) found some evidence that more tiredness before treatment predicted a more favourable response to light therapy. As far as we know the role of tension in relation to the response to light therapy has never been addressed. In the present study the relationship between pre-treatment activation and the subsequent response to light will be investigated. Pre-treatment activation will be assessed via self-rating and via voice sound characteristics of SAD patients during a clinical interview. Two aspects of activation will be considered: energetic activation and tense activation (see Thayer, 1989).

The vocal parameter which can be qualified as an indicator of tension is the voice pitch (i.e., the frequency of vocal fold vibration or fundamental frequency (F_0))(Scherer, 1981). High tension coincides with high voice pitch. The variability of the voice pitch has been found to be related to the level of voice pitch but also to feelings of happiness (large) and sadness (small) (for reviews see Scherer, 1986, 1987; Nilsson, 1987a). In general, F_0 plays a significant role in vocal emotion communication.

Interpersonal non-verbal behaviour, operationalized as the organisation of different behavioral elements of a patient and an interviewer, before light therapy was found to be related to the subsequent response (Geerts et al., 1995). Moreover, evidence existed that the beneficial effects of light therapy in SAD patients might be achieved via placebo effects (Eastman et al., 1992), which in turn could be based, among others, on interactional processes (Eastman, 1990). We therefore hypothesized that speech samples derived from an interaction are of more relevance than speech samples derived from counting or reading tasks (see also Scherer, 1987).

The acute response (during the days of light exposure) as well as a "late" response (11 (10) days after light exposure) were investigated.

Hence, the question was addressed whether pre-treatment activation (energy, tension) is related to the acute and/or to the late response to light exposure (respectively assessed during 4 days of light exposure and 11 (10) days after light exposure). Activation was assessed via self-rating and via voice-sound characteristics as expressed during an interaction.

2. Methods

2.1. Subjects and design

A sample of 41 female and 14 male SAD patients was investigated who participated in a study of Meesters et al., which addressed the importance of the timing of light in relation to the response (Meesters et al., 1995). All subjects met the criteria for seasonal pattern according to DSM-III-R (APA, 1987) and fulfilled the Rosenthal criteria for SAD (Rosenthal et al., 1984). The mean age of the females was 36.7 ± 11.0 (SD) years and of the males 37.7 ± 11.3 years. Three of the females and 2 of the males had earlier experience with light therapy in our centre. The patients were drug-free at least three weeks before the start of the study, and remained so during the study. All patients gave their consent after written and oral information on the study.

The patients received a four day 10 000 lux light treatment (full spectrum without UV) during 30 min per day and were randomly assigned to one of the following 5 conditions:

1. two days of morning light (8.00–8.30 a.m.) followed by two days of evening light (8.00–8.30 p.m.).
2. two days of evening light followed by a day without treatment and two days of morning light. The intervening day without light leads to 36 h between treatments, as in condition 1.
3. four days of morning light
4. four days of evening light
5. four days of light-treatment in the afternoon (1.00–1.30 p.m.).

Admission to the experiment required pre-treatment scores of at least 13 on the Beck Depression Inventory (Beck et al., 1961). The experimental

period lasted 19 days: 4 baseline days, 4 (5)¹ treatment days, and 11 (10)² days after treatment.

2.2. Assessment severity of depression and response

On the second baseline day a Hamilton interview was conducted by a male interviewer [Hamilton Rating Scale for Depression (HRSD), 21-item version, Hamilton, 1967]. Two interviewers participated in the study. Moreover, 11 days after light therapy a second HRSD score was assessed.

During the experimental period, depressed mood was assessed 3 times daily (7.45 a.m., 7.45 p.m., 10.45 p.m.) by means of the Adjective Mood Scale (AMS), (Von Zerssen, 1986, Von Zerssen, 1976; Elsenga, 1988).

2.3. Acute response

Depressed mood was assessed 3 times daily. In order to enable comparison between the 5 light conditions, the first 3 assessments which followed a light exposure were averaged. In cases of a morning light exposure, this concerned: the afternoon score and the evening score of that day, and the morning score of the following day. In cases where patients received light in the evening, the evening score of that day and the two subsequent scores (morning and afternoon) of the following day were used. These responses to the sequence of 4 light exposures will henceforth be called the response on “day 1” till “day 4” during light therapy. The acute response to light therapy concerned changes in depressed mood during the days 1–4. For each day the percent change, with respect to depressed mood averaged over the 4 baseline days, was calculated. In this way change-scores were relatively independent of the baseline degree of depressed mood.

2.4. Late response

The late response was defined as the percent change of the HRSD score 11 days after light therapy with respect to the baseline HRSD depres-

sion score and as the percent change of the averaged AMS scores on day 11 with respect to baseline AMS scores (averaged over 4 days).

2.5. Vocal parameters

The baseline HRSD interview was videotaped. The acoustic signal of these videotapes was used for speech analysis. In this way, a sample of naturalistic speech was obtained. The patients’ speech was sampled during the first 3 to 5 min of the interview, leaving out short utterances and interviewers’ speech. This resulted in 30 to 80 s of patient speech, consisting of several sentences. In these first minutes of the interview mostly emotional issues like mood and feelings of guilt were addressed.

The collected speech fragments were subsequently sampled with a sample frequency of 5120 Hz and stored on computer hard disk for further processing. A computer program developed at the Department of Biological Psychiatry of the Academic Hospital in Groningen essentially selected the vowels from the records on the basis of their frequency characteristics. Vowels contain a series of peaks in the frequency spectrum which are spaced at constant frequency intervals. The width of this interval equals the fundamental frequency, F_0 . This is due to the fact that, during a vowel, the intensity of the speech signal is modulated with the same frequency F_0 (see Fig. 1). The computer program searches for subsequent peaks in the intensity of the signal and determines the time intervals between the peaks. The results are stored and used for the calculation of the mean and the standard deviation of F_0 .

Having achieved a reliable assessment of the course of F_0 for each speech sample, the following measures were calculated: the mean F_0 and the standard deviation of F_0 . To compare the variability of F_0 in subjects varying in mean F_0 (for instance men vs women) the standard deviation of F_0 was divided by mean F_0 for each subject (see Nilsson, 1987a).

2.6. Self-rated activation

Self-rated activation was assessed by means of the activation–deactivation adjective checklist (AD-ACL, Thayer, 1967, 1986). Subjects had to rate adjectives on a 4-point scale, describing their current

¹ Digits between brackets refer to condition 2.

² To increase readability, in the rest of this article, “11” will be written when “11 (10)” is meant.

Fig. 1. Fragment of the speech signal, lasting 0.3 s. The first half of the signal represents a consonant, the right half is a vowel. The peaks at regular intervals during the vowel occur at the fundamental frequency, F_0 , of 115 Hz in this case. The first harmonic, with double frequency of 230 Hz is visible with about half the amplitude of F_0 .

feelings. Four activation dimensions are distinguished, two representing energetic activation (Energy, Tiredness) and two reflecting tense activation (Tension and Calmness), each of them represented by 5 items. Scores on each subscale range from 5–20. The AD-ACL was completed three times a day during the experimental period of 19 days, together with the AMS (see above). The AD-ACL scores averaged over the 4 baseline days were employed to predict response.

2.7. Statistical analyses

Because males and females differ in pitch levels, all analyses were performed for female subjects separately (the number of males was too small to allow separate analysis). In that way, all activation variables were studied in the same sample. When significant relations were found between baseline activation and response, the whole sample, females and males, was considered (of course with the exception of the mean F_0). To avoid multiple testing, two way ANOVAs were performed on the data obtained during light therapy: for each baseline activation variable two groups were formed (split

half) differing in activation level (group factor) and the depression scores during the 4 days of light exposure were treated as repeated measures. When significant main group effects or group $\times$ time interaction effects emerged, the two groups were compared (ANOVA) per day. The disadvantage of forming groups based on a dimensional variable was accommodated by a correlational approach (Pearson). It was inspected whether correlations would corroborate significant ANOVA results. With respect to the late response, ANOVAs were performed on the HRSD (%) change scores.

3. Results

3.1. Patient characteristics

First, in the whole group it was investigated whether the 5 conditions led to different acute and late responses. For the 5 conditions (group factor) the relative depression-change scores (AMS) on days 1, 2, 3 and 4 during light therapy (repeated measures), were tested. Patients improved already significantly during these 4 days of light treatment ($F(3,150) = 9.14$; $P = 0.00001$). No differences between conditions were found, neither with respect to acute responses, nor with respect to the late response. These results allowed pooling of data from the 5 conditions for further analyses.

In the sample of 41 women 26 patients were responders at day 11 (10) after light exposure stopped ($\text{HRSD} < 8$ and HRSD reduction $\geq 50\%$; (see Terman et al., 1989) and 12 were non-responders. In three patients no second HRSD interview was conducted.

The mean HRSD score before treatment was 16.6 ± 3.7 range 11–26. The mean AMS baseline score was 39.3 ± 7.7 (SD) range 21.7–53.9. The baseline scores for self-rated activation were respectively: Energy: 8.1 ± 1.8 (SD); range 5.0–12.0; Tiredness: 15.6 ± 1.7 ; range 11.8–19.3; Tension: 10.5 ± 2.6 ; range 6.1–15.9; Calmness: 13.8 ± 2.2 ; range 7.4–18.4. The mean F_0 scores were 186 ± 23 (SD) Hz; range 134–225 Hz and the SDF_0 (standard deviation of F_0 divided by the mean F_0 (for each subject)) 0.162 ± 0.022 (SD); range 0.111–0.207.

3.2. Prediction of response from baseline activation

For each measure of activation the group of 41 patients was split into two groups: 20 patients with high levels (H) and 21 patients with low levels (L). The acute responses (% change AMS during light) and the late response (% change HRSD 11 days after light exposure had stopped) for these groups (H and L) are presented in Table 1 and Table 2, respectively.

3.3. Acute response

In order to predict the acute response to light therapy, a two-way ANOVA was applied. For two groups (High–Low; group factor) the relative depression-change scores (AMS) on days 1, 2, 3, and 4 during light therapy (repeated measures) were tested. The results are presented in Table 3.

Groups selected for different pitch levels before treatment, showed different courses of depressed mood during light therapy (interaction effect). Pa-

Table 2

Effect of light therapy on depression (HRSD) in groups differing in baseline activation: late response

Late response (11 days after light therapy stopped) Expert judgement HRSD depression					
		Baseline HRSD mean $\pm$ SD		11 days after light %change mean $\pm$ SD	
Energy	H	16.5	3.0	56.8	32.4
	L	16.7	3.4	46.2	41.8
Tiredness	H	17.3	4.1	49.3	39.5
	L	15.9	3.2	53.4	36.3
Tension	H	18.4	3.7	59.9	29.8
	L	14.9	2.7	43.3	42.6
Calmness	H	15.8	3.5	49.2	44.1
	L	17.3	3.8	53.5	30.8
Mean pitch	H	16.7	3.2	42.6	34.2
	L	16.5	4.2	59.7	39.4
SD pitch	H	16.6	4.1	55.3	41.2
	L	16.6	3.4	47.2	33.6
	All	16.7	3.7	51.4	37.4

Table 1

Effect of light therapy on depressed mood in SAD patients differing in baseline activation: acute response

Acute response in women
self-rated depressed mood (AMS)

		Baseline			Day 1 ^a		Day 2		Day 3		Day 4	
		AMS scores mean $\pm$ SD		<i>n</i>	% change mean $\pm$ SD		mean $\pm$ SD		mean $\pm$ SD		mean $\pm$ SD	
Energy	H ^b	36.1	6.7	20	14.0	23.7	23.8	35.0	32.3	41.6	38.2	33.3
	L	42.4	7.3	21	10.6	21.5	22.1	24.6	28.0	26.9	33.9	29.6
Tiredness	H	41.6	6.8	20	17.9	22.8	22.7	27.1	30.8	31.7	33.9	27.6
	L	37.2	8.0	21	6.9	21.1	23.1	32.7	29.4	37.7	37.9	34.7
Tension	H	40.0	8.4	20	20.6	23.1 ^c	31.6	30.0	35.0	34.8	39.8	30.0
	L	38.8	7.1	21	4.4	19.0	14.7	27.7	25.4	34.3	32.3	32.4
Calmness	H	36.6	7.9	20	13.8	22.2	25.1	29.6	25.7	36.6	30.2	28.4
	L	41.9	6.6	21	10.8	23.0	20.9	30.5	34.2	32.6	41.5	33.2
Mean pitch	H	38.7	7.6	20	20.1	20.8 ^d	23.2	28.1	24.5	28.9	33.7	32.3
	L	40.0	7.9	21	4.8	21.7	22.6	31.9	35.4	38.3	38.1	30.6
SD pitch	H	42.2	6.3	20	5.3	19.7 ^c	22.4	30.1	36.3	33.2	39.8	32.3
	L	36.7	8.1	21	19.0	23.2	23.4	30.1	24.1	35.4	32.3	30.2
	All	39.3	7.7	41	12.3	22.4	22.9	29.7	30.1	34.4	36.0	31.1

^a Relative change in depressed mood (AMS) with respect to baseline.

^b Groups divided into high and low baseline values of activation (split half).

^c ANOVA: $P = 0.019$; ^d: $P = 0.027$; ^e: $P = 0.049$.

Table 3
Results statistical analyses

	Two-way ANOVA (acute response ^a)				ANOVA (late response ^b)	
	Main group effect (High vs Low)		Interaction effect group $\times$ time		<i>F</i> (1,37)	<i>P</i>
	<i>F</i> (1,39)	<i>P</i>	<i>F</i> (3,117)	<i>P</i>		
Energy	0.22	0.638	0.03	0.993	0.77	0.386
Tiredness	0.08	0.780	0.87	0.460	0.11	0.738
Tension	3.25	0.079	0.47	0.705	1.97	0.169
Calmness	0.19	0.665	1.32	0.271	0.12	0.727
Mean pitch	0.00	0.980	2.71	0.048	2.10	0.155
SD pitch	0.03	0.866	2.85	0.040	0.45	0.507

^a Mood response (AMS change with respect to baseline) during 4 days of light therapy.

^b Depression change: HRSD, 11 days after light therapy stopped, relative to baseline HRSD.

tients with high pitch levels at baseline benefitted more from treatment than those with low levels, but only during the first day of light exposure (ANOVA: $F(1,39) = 5.28$; $P = 0.027$). For the days 2, 3, and 4 no significant differences between these groups were found.

Also groups selected on the basis of the baseline variation in pitch showed different mood courses during the 4 days of light exposure. This difference could be ascribed to the first day, during which the low variation group improved more than the high variation group (ANOVA: $F(1,39) = 4.13$; $P = 0.049$).

With respect to Tension a tendency was found that the high Tension group had a more favourable acute response than the low Tension group (main effect over 4 light exposure days $P = 0.079$). This effect was mainly due to differences after the first light exposure ($F(1,39) = 6.03$; $P = 0.019$).

The results for the vocal parameters were corroborated by a correlational approach. The mean pitch level and the variation of pitch before treatment were significantly correlated with acute improvement (i.e., corrected for baseline depression) during the first day of light therapy (resp. r (Pearson) = 0.383; $P = 0.013$ and $r = -0.334$; $P = 0.033$, $n = 41$). Self-rated Tension was not significantly associated with acute improvement on day 1.

In addition, the same analysis in the whole sample (women and men) showed that the variation in pitch was still significantly related to change in depressed mood after the first light exposure ($r = -0.316$, $P = 0.019$, $n = 55$).

As was stated at the beginning of this section the data obtained in five treatment conditions were pooled together since the conditions showed similar responses. Given the fact that day-1 responses turn out to be related to activational measures, it is necessary to test whether the various treatment conditions showed differences in day-1 responses. The significant results with respect to the acute improvement on day 1, could not be ascribed to the experimental conditions (ANOVA).

3.4. Late response

The depression change as assessed 11 days after light therapy (% HRSD change with respect to baseline HRSD) was compared between two baseline groups, classified according to activation levels before treatment. No significant relationship was found between the pre-treatment activation measures and the subsequent late improvement. The comparisons of the late AMS response similarly revealed insignificant results.

3.5. Interrelations

Correlations were calculated between all baseline variables and presented in Table 4. For the vocal parameters it was found that the mean pitch and the variation in pitch are negatively related (women: $r = -0.471$; $P = 0.002$, $n = 41$). In addition, the variation in pitch was negatively related to Energy in women ($r = -0.343$; $P = 0.028$; $n = 41$). This relationship was not significant in the whole group

Table 4
Correlations (Pearson) between baseline variables in women

Correlations (Pearson) between baseline variables in women ($n = 41$)							
	1	2	3	4	5	6	7
1 Energy							
2 Tiredness	-0.591 $P = 0.000$						
3 Tension	0.354 $P = 0.023$	-0.019 $P = 0.908$					
4 Calmness	0.066 $P = 0.684$	-0.119 $P = 0.459$	-0.584 $P = 0.000$				
5 Mean pitch	0.109 $P = 0.499$	0.000 $P = 0.998$	0.067 $P = 0.676$	-0.097 $P = 0.54$			
6 SD pitch	-0.343 $P = 0.028$	0.134 $P = 0.405$	-0.183 $P = 0.253$	-0.059 $P = 0.715$	-0.47 $P = 0.002$		
7 Depression (AMS)	-0.589 $P = 0.000$	0.456 $P = 0.003$	0.126 $P = 0.433$	-0.331 $P = 0.034$	-0.192 $P = 0.227$	0.281 $P = 0.075$	
8 Depression (HRSD)	0.0051 $P = 0.975$	0.1298 $P = 0.419$	0.4802 $P = 0.001$	-0.2941 $P = 0.62$	-0.0263 $P = 0.870$	-0.0399 $P = 0.804$	0.2438 $P = 0.125$

($r = -0.222$; $P = 0.103$; $n = 55$). No other significant associations were found between the vocal variables and self-rated activation or severity of depression. Moreover it should be noted that baseline Tension is not significantly associated with baseline self-rated depression (AMS).

3.6. Additional analyses

Because it has been reported that pre-treatment Tiredness was related to the HRSD treatment response (11 days after light therapy stopped) (Meesters et al., 1993), the relationship between baseline Tiredness and late response was investigated separately. No significant relations between baseline Tiredness and the late response were found in women neither with respect to the HRSD response (see Tables 1 and 3) nor with respect to the late AMS response. However, for the whole group, a significant correlation was found between pre-treatment Tiredness and the late AMS response to light treatment ($r = 0.308$; $P = 0.022$; $n = 55$) and a nearly significant relationship with respect to the late HRSD response ($r = 0.242$, $P = 0.081$, $n = 55$).

According to Lam (1994) younger age predicts light therapy response. This relationship might have confounded our results thus far. However, we could not confirm Lam's results: The correlations between age and acute response (day 1) or age and late response (11 days after light therapy termination) were not significant, neither in the group of women nor in the whole group. Hence, statistical correction procedures did not need to be applied.

Also the variability in F_0 has been reported to be related to age, older age coinciding with larger variability in pitch (Morris and Brown, 1994). In the present samples this relationship could not be confirmed (Pearson correlations).

4. Discussion

It was hypothesized that pre-treatment activation plays a role in the acute (during 4 days of light therapy) and/or late (11 days after light therapy) response to light therapy in SAD. Energetic and tense activation was assessed before treatment via self-rating and voice sound characteristics. Support

was found for this presumption, but restricted to the acute response: Patients having high pitched voices with small variation in this pitch (indicative for tension) benefitted more from light therapy than the patients with low pitch levels and large variation. This effect was only significant after the first light exposure. A tendency in the same direction was found for self-rated Tension. No significant relations were found between baseline sound variables and late responses to light (11 days). Results on variation in pitch hold also for men and women taken together. Hence, light treatment seems to give extra comfort in “tense” patients, who become rapid responders to light therapy.

It should be noted that analyses were performed on improvement scores relative to baseline scores, i.e., corrected for the baseline severity of depression. Moreover, no direct relation exists between vocal parameters and baseline depression. Hence, a simple explanation of the results via an association of depression and vocal tension at baseline is not convincing.

That fact that self-rated activation was not significantly related to the acute mood response, while sound variables were, necessitates reconsideration of the meaning of these acoustic variables.

First, one could argue that pitch is, to some degree, determined by stable individual biophysical characteristics. However, it has been shown earlier that psychological and environmental variables also play a significant role in determining pitch (e.g. Scherer, 1987).

Although it could be claimed that pitch level is indicative for tension, relations between activation and pitch are rather complex, particularly in a depressive population. Conflicting evidence exists as to whether pitch is related to clinical depression (Nilsonne, 1987a; Scherer, 1987; Bouhuys et al., 1990; Kuny and Stassen, 1993; Stassen et al., 1991; Breznitz, 1992; Talavera et al., 1994). For this lack of conclusiveness several possible confounding factors have been suggested: medication conditions, sample size, the heterogeneity of the samples, and the degree of retardation or agitation. However, with respect to the latter variable, Nilsonne found that pitch is rather related to the severity of depression than to the degree of activation (Nilsonne, 1987b).

Our results do not confirm this: we did not find direct relations between vocal parameters and depression, and self-rated Energy was even inversely related with variation in pitch.

In our opinion it may be of importance that the present pitch variables are obtained in a naturalistic interaction, which allows more possibilities to express tension in the voice than reading and counting tasks (Scherer, 1987). Moreover, the present acoustic variables probably reflect another aspect of tension than self-rated Tension, based on averaged daily scores: e.g. more social anxiety versus general Tension, respectively. This may explain why (1) acoustic parameters predicted acute response to light therapy significantly and self-rated Tension did not, and why (2) vocal parameters were not directly related to Tension before treatment.

The suggestion in the study of Meesters et al. (1993) that patients with high pre-treatment Tiredness benefitted more from light therapy ($n = 24$) could be partly confirmed in the present study. No significant relations were found for women between baseline Tiredness and the late responses (11 days after light exposure had stopped). However, for the whole group a significant correlation was found in the data on the late self-rated response and a tendency in the same direction in the data on the HRSD response.

Let us assume that (variation in) pitch, obtained in a naturalistic situation, is a sensitive measure for tension. Tense SAD patients show faster responses to light therapy. Perhaps this acute reaction to treatment can be interpreted as a “placebo response”. The anticipation of a novel and new treatment supposedly provoked pre-treatment tension. After the first experience with light therapy patients may have been relieved, and this relief may have been expressed in mood scores.

Other explanations are possible. Acute improvement of depressed mood after the first light exposure coincides, among others, with reduction of Tension ($r = 0.457$; $P = 0.000$; $n = 55$). One may speculate that the primary effect of light therapy is tension reduction, and that this reduction is a necessary condition for prolongation and increase of the acute mood response to light therapy. Terman suggested that light may have an energizing effect, independent

of its effects on mood (Terman et al., 1987). The present study suggests that tension reduction may mediate the mood response to light therapy.

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