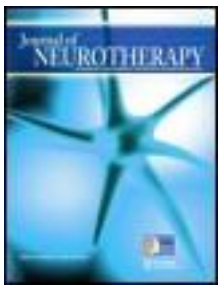

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A Controlled Comparison of Audio-Visual Entrainment for Treating Seasonal Affective Disorder

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CLINICAL CORNER

A Controlled Comparison of Audio-Visual Entrainment for Treating Seasonal Affective Disorder

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ABSTRACT. *Introduction*. Seasonal Affective Disorder (SAD) affects up to 6% of the population, primarily in the winter months and at higher latitudes.

Methods. Light-box therapy has been the traditional intervention for SAD, where the individual is exposed to a bright light for substantial periods in an effort to replace the lack of sunshine. Audio-visual entrainment (AVE) is a technique using flashing lights through a pair of specially designed glasses and pulses of tones through headphones. The expectation of AVE is to affect brain wave activity through auditory and visual stimulation at specific frequencies. The objective of this study was to determine if AVE is a viable treatment for SAD. The study involved 74 participants in a comparison design with a control group (no flashing lights or pulsed tones) and an AVE group that received a placebo treatment (AVE at 1 Hz flashing lights and pulsed tones) for 2 weeks, followed by an active treatment phase (20 Hz flashing lights and pulsed tones) for another 2 weeks.

Results. The results indicated that the placebo phase produced mild reductions in depression and no improvements in anxiety sensitivity, whereas 20 Hz AVE reduced both depression and anxiety symptoms.

Conclusion. The 20 Hz AVE treatment condition also produced significant improvements in social life with the family and at work, and increased happiness and energy. The 20 Hz treatment also produced a significant decrease in eating, appetite, and carbohydrate intake.

KEYWORDS. Audio-visual entrainment (AVE), brainwave entrainment (BWE), DAVID, placebo, Seasonal Affective Disorder

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INTRODUCTION

Seasonal Affective Disorder (SAD) affects up to 6% of the population (Teicher et al., 1995). The ratio of northerners with SAD as compared to those living in the tropics is about 10 to 1. People in the southern U.S. states may experience SAD in the summer from staying indoors where air conditioning allows them to escape the unbearable summer heat. People have also experienced SAD after moving into a basement suite or an office on the north side of a building or after painting the interior of their home a darker shade of color. People have also experienced SAD following the development of cataracts, after wearing sunglasses for an extended period, or during overcast rainy periods (Rosenthal, 1993).

Women between 20 and 40 years of age are most commonly affected by SAD (Lindjaerde & Reichborn-Kjennerud, 1993; Rosenthal, 1993; Thompson & Isaacs, 1988). Estimated figures suggest that up to one fourth of American women may suffer from winter blues, a milder form of SAD (Kasper et al., 1989; Rosen et al., 1990; Swedo & Leonard, 1996). Rates of SAD and subsyndromal SAD, or typical winter blues, increase in frequency and severity with increase in latitude (Rosen et al., 1990). Sakamoto, Kamo, Nakadaira, Tamura, and Takahashi (1993) proposed that the operating variable here may not be latitude but the number of hours of sunshine in a particular place, which includes cloud cover.

Clinical features such as depression, anxiety (Levitt, Joffe, Brecher, & MacDonald, 1993; Marriott, Greenwood, & Armstrong, 1994), weight gain, increased carbohydrate intake and cravings, increased appetite, cognitive problems, mood swings, lack of sociability, hypersomnia, and a lack of energy are reminiscent of SAD (Lee, 1995; Rosenthal, 1993; Sack et al., 1990). Winter depression in northern latitudes lasts an average of 3.9 months (Rosenthal et al., 1984).

Vitamin D deficiency may be misdiagnosed as SAD. A study by Gloth, Alam, and Hollis (1999) found that winter depression was eliminated by a single dose of 100,000 IU of vitamin D, whereas small doses had no effect. Light-box therapy utilizing full-spectrum lighting has been reported to reduce seasonal depression. This approach is based on the concept that light waves striking the retina activate electrical output, which is sent down the optic nerve to the brain for visual processing. A secondary, smaller nerve tract from the retina, originating from specialized cells that utilize a light detecting pigment called melanopsin, also carries signals to the suprachiasmic nucleus (SCN) of the hypothalamus. The SCN, in turn, sends nervous outputs to various parts of the brain including the pineal gland. Four genes that govern circadian cycles in flies, mice, and humans have been discovered that not only reside within the SCN but in all cells of the body. When cultured in a petri dish under constant light, these cells continue with gene activity, hormone secretion and energy production in a 24-hr cycle that varies less than 1% (Wright, 2002).

Light boxes are designed to deliver between 2,500 and 10,000 lux of continuous (nonpulsed) light (Brainard et al., 1990; Eastman, Lahmeyer, Watell, Good, & Young, 1992), whereas light visors (which resemble sun visors with lights installed in them) have been found to be effective when delivering as little as 30 lux of continuous light (Swedo & Leonard, 1996). The effective duration of light-box therapy has been reported to be from 30 min at 10,000 lux to 4 hr at 2,500 lux (Avery et al., 1993; Terman, Quitkin, & Terman, 1987).

The specific spectral properties of phototherapy necessary for treating SAD are not yet certain (Lee, 1995). However, light-box therapy needs to be used on a consistent (daily) basis, as long as there is a shortage of environmental light (Rosenthal, 1993). Skipping treatment for just one day could bring about a return of symptoms (Rosenthal, 1993). Some research suggests that the time of day when light therapy is administered is not important in producing a therapeutic response (Eastman et al., 1992; Hellekson, Kline, & Rosenthal, 1986; Rosenthal, 1985; Wehr et al., 1986). Rosenthal (1993) concluded that light-box therapy could be used at any time of day,

whatever suited a person's schedule. If morning light therapy did not fit into one's schedule, then it was suggested to try an evening light session instead.

Rosenthal (1993) found that when the SAD patient is exposed to too little environmental light such as during the winter, production of serotonin is reduced. Serotonin is typically at its lowest level during the winter months (Silverstone, 1989). There is evidence that high amounts of carbohydrates increase the production of brain serotonin (Rosenthal et al., 1989), which may explain the carbohydrate cravings that are often reported by SAD sufferers. The antidepressant medications called selective serotonin re-uptake inhibitors (such as Prozac), which increase the amount of serotonin available for nerve signal transmission appear to reverse the symptoms of SAD (Rosenthal, 1993; Rosenthal et al., 1989).

Light exposure has been shown to stimulate serotonin-containing nerve cells in the brain and increase the concentration of serotonin in the hypothalamus in rats (Rosenthal, 1993). In humans, alpha brainwave frequencies are known to affect hormone levels. Shealy, Cady, Cox, Liss, Clossen, and Veehoff (1989) reported that by flashing lights into closed eyes, daytime levels of more than 11 hormones are affected, including serotonin (23% increase), endorphins (13% increase), norepinephrine (18% increase), and melatonin (6% decrease). In terms of EEG activity, depression is associated with decreased relative power beta brainwave activity (Strelets et al., 1996) and an excess in alpha, theta, and delta activity (Alper, 1995; Brenner et al., 1986; Itil, 1983; John, Prichep, Fridman, & Easton, 1988; Knott & Lapierre, 1987; Monakhov & Perris, 1980; Nieber & Schlegel, 1992; Nystrom, Matousek, & Hallstrom, 1986; Pollock & Schneider, 1990).

Audio-visual Entrainment (AVE) can alter a person's existing brainwave activity by presenting pulsed lights into the eyes (Barlow, 1960; Kinney, McKay, Mensch, & Luria, 1973; Toman, 1940) and tones into the ears (Frederick, Lubar, Rasey, Brim, & Blackburn, 1999). AVE can induce relaxation (Brauchli, 1993; Morse & Chow, 1993), hypnosis (Kroger & Schneider 1959; Margolis, 1966) and dissociation (Leonard, Telch, & Harrington, 1999, 2000). AVE has also been shown to treat headaches (Anderson, 1989; Solomon, 1985), and Temporomandibular joint disorders (Manns, Miralles, & Adrian, 1981; Thomas & Siever, 1989). AVE has also been known to the authors to have an inhibitory effect at the half-frequency of stimulation, which has also been replicated by Collura and Siever (2009). Collura and Siever demonstrated that a child with attention deficit disorder and with excessive 7 Hz activity had rapid inhibition of the aberrant activity during 14 Hz photic stimulation.

The goal of this study was to evaluate whether AVE would reduce the symptoms of SAD by stimulating an increase in beta brainwave activity and relative beta brainwave activity by simultaneously decreasing excessive alpha brainwave activity.

METHOD

Sample

The study consisted of 74 participants diagnosed with SAD based on criteria from the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994). Fifty-eight of the participants were in the AVE group (16 male, 42 female; M age = 38.5 years $\pm$ 9.4). They received a placebo stimulation ($<$1 Hz) for the first 2 weeks. This was deemed a placebo rather than an alternative treatment because AVE stimulation at a 1 Hz frequency has been proven ineffective at producing brainwave entrainment (Barlow, 1960; Kinney et al., 1973; Toman, 1940). Following the first 2 weeks of placebo stimulation, they received treatment stimulation (20 Hz) for 2 more weeks. The remaining 16 participants were in the control group and did not receive treatment (6 male, 10 female; M age = 36.3 $\pm$ 12.3).

Measures

The Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) and the Anxiety Sensitivity Index

(ASI; Reiss, Peterson, Gursky, & McNally, 1986) questionnaires were used in the study for the pre- and postplacebo and the posttreatment data analysis. The BDI is a 21-item multiple-choice, self-reported questionnaire that measures depression symptomatology, and the ASI is a 16-item self-reported questionnaire that measures how easily a person could become anxious to daily environmental stimuli. A daily diary was maintained plus a modified Hamilton Depression Rating Scale (Hamilton, 1967) based on the Visual Analogue Scale (VAS). The VAS is a 10-cm line anchored on either end by an absolute value. The VAS had measures for social life with family (anchored by *a lot* to *not at all*), social life at work (*a lot* to *not at all*), mood (*happy* to *worthless*), eating (*more than normal* to *forced yourself to eat*), appetite (*more than normal* to *poor*), carbohydrate intake (*more than normal* to *poor*), cravings (*more than normal* to *nothing*), and energy (*very high* to *very low*). The daily diary also recorded total sleep time and the time of day AVE was used.

Equipment

Treatment was administered with an AVE device called DAVID Paradise manufactured by Mind Alive Inc. (Edmonton, Alberta, Canada). Participants used the AVE device at home. They were required to sit in a comfortable chair, or lie in bed, wearing both headphones and specialized glasses. Tones were generated through the headphones and lights flashed through the glasses.

The intensity of the lights was adjustable within a range from 0 to 700 lux. On every pulse of light, there was a 7-msec ramp-up between no light and maximum intensity and vice versa. The stimulus duty-cycle was 50%: On-time of flashing light and tone was equal to off-time. Tones pulsed in sync and at the same frequency as the flashing lights. Both the placebo treatment stimulation and the treatment stimulation lasted 20 min. Participants were asked to use the same intensity of light throughout the session and the entire study. All participants were instructed to keep their eyes closed during the sessions as this is thought to enhance the AVE effect.

Procedure

Informed consent was obtained from AVE participants. Morning light exposure has been shown to be an effective treatment for winter depression (Terman et al., 1987), so consequently all participants were asked to use the DAVID Paradise device upon waking in the morning. During the first 2 weeks, the AVE Group was given the 1 Hz (placebo condition). The 1 Hz frequency is considered ineffective at producing brainwave entrainment (Barlow, 1960; Kinney et al., 1973; Toman, 1940), but in-house observations suggest that it might stimulate hypothalamic action. After 2 weeks, the AVE group used the 20 Hz treatment session first thing each morning. The most common intensity of the pulsing white light used was about 350 lux.

RESULTS

BDI scores were significantly reduced (improved) with both forms of AVE training ($M = 20.1 \pm 9.5$ for baseline, $M = 15.9 \pm 10.7$ for 1 Hz, $p < .001$). BDI scores were significantly reduced further after 20 Hz ($M = 7.3 \pm 5.3$, $p < .001$).

AVE treatments were evaluated by an analysis of variance. The results of the 1 Hz and 20 Hz sessions were significant when compared to the control group ($F = 13.588$, $p < .001$ and $F = 96.693$, $p < .001$, respectively).

At the beginning of the study BDI scores indicated 19% of the treatment participants did not have depression. Following 2 weeks use of 1 Hz AVE, 36% indicated they no longer had depression. However, after 2 weeks of 20 Hz AVE, BDI scores indicated 84% of treatment participants were no longer depressed (Table 1). In fact the BDI scores of all participants decreased after the 20 Hz treatment evaluation. The control group's average BDI mean scores increased by 4% during the same period.

TABLE 1. Between-group differences of Beck Depression Inventory test scores.

	AVE Group[a]	Control Group[b]	*p*
Post-placebo AVE/2 weeks	15.9 (±10.7)	25.9 (±10.3)	<.001
Post-active AVE/4 weeks	7.3 (±5.3)[c]	26.1 (±8.5)	<.001

Note. AVE = Audio-visual Entrainment.
[a] $n = 58$.
[b] $n = 16$.
[c] The participants used the treatment 20 Hz session.

Change in the ASI mean scores were significant for male participants of the AVE group ($M = 25.1 \pm 10.6$ for baseline; $M = 19.8 \pm 11.3$, *ns*, for the 1 Hz; $M = 12.0 \pm 6.2$ ($p < .05$) for the 20 Hz treatment). The ASI male population analysis for the effect of the treatment group revealed significance ($F = 31.270$, $p < .001$).

The AVE group male participants' ASI mean scores were significant with the 20 Hz stimulation and not with the 1 Hz placebo sessions ($M = 25.1 \pm 10.6$ for the baseline; $M = 19.8 \pm 11.3$ for the 1 Hz, *ns*; $M = 12.0 \pm 6.2$ for the 20 Hz, $p < .05$). When compared to controls, ASI scores improved significantly in male participants after receiving the 20 Hz treatment ($F = 31.270$, $p < .001$; Table 2). Prior to the study, 44% of the male participants did not show anxiety sensitivity. Following the 1 Hz placebo and the 20 Hz treatment, those participants who were free from anxiety sensitivity increased from 69% to 100%, respectfully. The ASI scores of male controls increased by 7% during the study.

Female AVE participants' ASI scores were significant with 20 Hz treatment and not for the 1 Hz placebo ($M = 21.9 \pm 10.9$ for the baseline; $M = 18.8 \pm 11.4$ for the 1 Hz, *ns*; $M = 12.3 \pm 8.5$ for the 20 Hz, $p < .001$). When compared to the control group, the analysis of the female participants' ASI scores were significant after using the 20 Hz treatment ($F = 15.867$, $p < .001$; see Table 2). Prior to the study, 55% of the female participants did not show anxiety sensitivity. Following the 1 Hz sessions and the 20 Hz sessions, anxiety sensitivity decreased to 64% and 83%, respectfully. Female controls had anxiety sensitivity decrease by 6% during the study.

As shown in Table 3, significant changes occurred in the daily dairy in the following: social life with the family, social life at work, positive mood, decrease in eating, appetite decrease, carbohydrate intake decrease, and energy increase. There were no significant change in cravings and total sleep time.

DISCUSSION

The DAVID Paradise device was effective in both the 20 Hz and 1 Hz AVE, producing

TABLE 2. Mean Anxiety Sensitivity Index test scores for each gender (with standard deviation).

	AVE[a]	Controls	*p*
Male			
Post-placebo AVE	19.8 (11.4)	26.8 (7.8)	*ns*
Post-active AVE	12.0 (8.5)	28.8 (6.4)	<.001
Female			
Post-placebo AVE	18.8 (11.4)	26.1 (8.2)	*ns*
Post-active AVE	12.3 (8.5)	25.9 (9.5)	<.001

Note. AVE = Audio-visual Entrainment. (Standard deviation in parentheses).
[a] Male, $n = 16$; female $n = 42$.
[b] Male, $n = 6$; female $n = 10$.

TABLE 3. Self-report Visual Analogue Scale symptom scale after 1 Hz Audio-visual Entrainment compared to after 20 Hz sessions.

	1 Hz (*M*, *SD*)	20 Hz (*M*, *SD*)	*p*
Decrease of total sleep time	7.8 (1.6)	8.0 (1.6)	*ns*
Increase of social life with the family	5.0 (2.4)	3.9 (2.3)	<.001
Increase of social life at work	5.3 (2.1)	4.4 (2.6)	<.001
Decrease of mood problems	4.9 (2.1)	4.1 (2.2)	<.001
Decrease of overeating	4.6 (1.9)	3.9 (2.0)	<.001
Decrease of appetite	4.7 (1.9)	4.2 (2.1)	<.001
Decrease of carbohydrate intake	4.6 (1.9)	4.0 (2.0)	<.001
Decrease of cravings	5.0 (2.6)	4.9 (3.1)	*ns*
Increase of energy	4.1 (2.6)	5.0 (2.2)	<.001

significant reductions in SAD symptoms. The 20 Hz treatment group showed decreased depression in 84% of the participants as compared to 36% of those following the 1 Hz session. It occurs to use that to an SAD patient, any light may have an antidepressant effect (Rosenthal, 1993). Whether from the sun or a sun-tanning bed, sufferers of SAD adhere to light conditions to reduce their symptoms, which may explain the changes following the "placebo" 1 Hz stimulation. The placebo effect has been documented to reduce anxiety, increase endorphin release, conditioning, and expectancy (Godfroid, 1998). Endogenous opiates have been mediated by the placebo effect (Pancheri & Kotzalidis, 1992; Ter Riet, deCraen, deBoer, & Kessels, 1998). Further, Pancheri and Kotzalidis suggested that a placebo may act by decreasing anxiety, or by meeting the expectations of the SAD sufferer (Bostroem, 1997).

We would suggest that the flashing lights at 1 Hz may represent a placebo effect in reducing depression, whereas the flashing light of 20 Hz treatment (which falls in the frequency range where brainwaves may be entrained) may represent an active treatment effect in reducing depression. Antidepressant medications have been shown to increase relative beta brainwave activity in major depression patients (Freye & Fournell, 1988; Galderisi, Mucci, Bucci, Mignone, & Maj, 1996). These findings suggest that beta brainwave entrainment may change the relative beta brainwave activity necessary in decreasing depression. However, a limitation of the study is that any changes in EEG activity were not measured.

In contrast, the 1 Hz treatment phase did not significantly decrease anxiety sensitivity, which might be because depression is the first major symptom reported by those with SAD in the absence of sunlight (Rosenthal et al., 1984). The placebo effect for anxiety sensitivity may not have occurred because anxiety sensitivity is not a primary symptom associated with reduction of sunlight. However, the 20 Hz treatment did produce a significant decrease in anxiety sensitivity. Beta brainwave activity, which includes the 20 Hz frequency, has been associated with mood elevation and decrease of anxiety (Packard & Ham, 1997; Sandyk & Derpapas, 1993). Research suggests that anxiety can be reduced by the decrease of the beta brainwave activity (Yamada, Kimura, Mori, & Endo, 1995), and high frequency beta activity has been found to be less evident in panic or anxiety disorder patients (Knott, Bakish, Lusk, & Barkely, 1997).

Compared to the 1 Hz treatment phase, the 20 Hz treatment data improved sociability with the family and sociability at work. Socially inactive people tend to have a deficit in beta brainwave activity (Saito, 1995). The

AVE group associated their low energy as being physical and, therefore, the significance of increased energy was encouraging.

Decreases in motor skills are correlated with slow brainwave activity (Stutzmann, Piot, Reibaud, Doble, & Blanchard, 1992), whereas beta brainwave activity has been correlated with an increase in motor skills (Nieber & Schlegel, 1992). Most AVE participants claimed that their physical workload doubled after using the 20 Hz AVE sessions for 2 weeks.

It is uncertain why cravings did not change. When asked what was craved, more than 50% of the AVE participants indicated coffee. According to the participants, coffee was not considered a carbohydrate, something to eat, or believed to affect appetite. The participants described cravings as food related which did not include coffee intake. Coffee not being defined as a craving may explain the nonsignificant outcome.

Sleep time increased while using the 20 Hz treatment by 15 min. Twelve participants of the AVE group claimed that physical activity increased as a result of their increased energy. They felt that their extra sleep time contributed to an increase in their energy output.

The effects of lowered depression were felt on average within 2 days after beginning to use both the 1 Hz and 20 Hz sessions. However, 4 AVE participants felt less depressed the 1st day after using the 1 Hz, and 6 AVE participants after using the 20 Hz for 1 day.

Increased energy levels, sociability, and happier moods were reported after using the 20 Hz session. Decrease of appetite, carbohydrate intake, and eating were also experienced after using the 20 Hz session. Verbal follow-up indicated AVE participants' SAD symptoms came back within 2 weeks after not using the DAVID Paradise device.

CONCLUSIONS

An SAD sufferer may experience symptoms because of the lack of beta brainwave production. An electronic flashing light instrument such as the DAVID Paradise may be an effective alternative to light-box therapy.

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