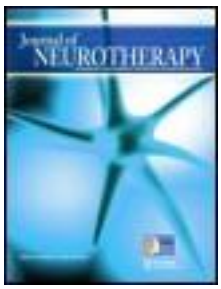


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## Subthreshold 10-Hz Sound Suppresses EEG Theta


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# Subthreshold 10-Hz Sound Suppresses EEG Theta: Clinical Application for the Potentiation of Neurotherapeutic Treatment of ADD/ADHD

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*The purpose of this article is to present the details of a newly developed home treatment protocol that provides immediate enhancement of attention and also markedly shortens the frequency and duration of office-based neurofeedback treatment of ADD/ADHD. The critical component of the treatment is the self-administration of a blend of tones embedded in filtered white noise (SUB/ALPHA) that immediately suppresses EEG theta with resultant immediate enhancement ofattentional focus. Data from four studies indicating the suppressive effect of SUB/ALPHA on clinical and nonclinical populations are presented.*

Over the last 15 years or so, I have been studying the effects of subliminal messages on behavior. As part of that effort, I began to study the effects of meaningful sounds, presented subliminally, on psychophysiological state. For example, many people report feeling nauseated or physically uncomfortable when exposed to a subliminally presented sound of a person retching and vomiting (Swingle, 1992). Subliminal heart sounds increase subject's heart rate when presented at a high rate of 92 Beats Per Minute (BPM). For clinically anxious clients, presentation of a low heart rate of 48 BPM will reduce arousal and decrease subjective anxiety (Swingle, 1992, August).

Although meaningful sound, when presented subliminally, does influence behavior and autonomic arousal, the decision to investigate the effects of nonmeaningful sound on central nervous system activity was precipitated by a serendipitous episode. One day while I was trying to perfect a slow modulating tone to be used in a recording to guide paced breathing for relaxation, one of my graduate students complained of unusual fatigue. He had been in his office, which was about twenty feet away from where I had been working, and although it was early morning he found that he was suddenly very tired and unable to concentrate. While pondering the cause of his dilemma, it occurred to us that the sound that was clearly audible to me may have been in the effective subliminal range in his office, and the cause of his fatigue. We subsequently determined that, indeed, the sound, at his desk, was in the effective subliminal range. The sound was a single sinusoidal tone that modulated between 285 Hz and 315 Hz at about 7 cycles per minute. We have found that a subliminal recording of this tone is clinically useful for some patients with sleep disturbances.

This serendipitous episode was the beginning of my investigation of the effects of subthreshold presentation of tones on the EEG. We know that auditory and visual supraliminal stimulation at set frequencies does enhance the amplitude of brainwaves at the same frequency as the stimulation (Barlow, 1960; Ohatrian, Peterson, & Lazarre, 1960). The decision to use sounds within the conventional EEG spectrum (2 to 25 Hz) was guided by the above studies which indicated that such sounds will entrain brainwave activity. However, there is considerable evidence indicating that subliminal and supraliminal stimuli are processed independently and often have dif-

ferent effects (Swingle, 1992).

To present stimuli at frequencies between 2 and 25 Hz within the audible range, two sinusoidal tones at different frequencies were simultaneously presented at equal amplitude. When the difference in frequency is below about 60 Hz, beats will be heard (Plomp, 1976). The beat frequency is equal to the difference in frequency between the two tones and the loudness of the beats is maximum when the amplitude of the two sinusoids is equal (Green, 1976).

The stimulus tape recordings were prepared as described in detail in Swingle (1992). Two equal amplitude sinusoidal tones with frequency differences of 2 Hz, 5 Hz, 8 Hz, 10 Hz, 15 Hz, and 25 Hz were embedded in pink noise. (Pink noise differs from white noise in that the latter has equal power per Hz whereas the former has equal power per octave. Pink noise, therefore, has less power in the higher frequencies resulting in a less harsh, more natural sound such as rushing water.) The tones were embedded at two Sound Pressure Levels (SPL) of -17 dB(C) and -25 dB(C) which correspond to the effective subliminal ranges for males and females, respectively (Swingle, 1992). That is, the blended tones were recorded on one tape at 17 dB(C) and on a second tape at 25 dB(C) below the masking pink noise.

A number of studies have been conducted on both clinical and nonclinical populations. Studies with college student volunteers indicated a reliable decrease in heart rate and subjective ratings of arousal with presentations of the 15- and 25-Hz masked tones. The average heart rate reductions observed after two minute presentations were between -1.2% and -4.6% relative to baseline. The average heart rate changes with presentations of the 2-, 5 -, 8-, and 10-Hz masked tones were between +2.2% and +4.0%. The 25-Hz preparation (SUB/BETA) has been tested clinically with patients who complain of anxiety exacerbated conditions. The effect of SUB/BET A on the patient's heart rate is determined during standard psychophysiological assessment procedures. The average heart rate reduction observed during a one-minute presentation is about 3% below baseline (Swingle, 1993, June).

Given that the slower frequency tones (10 Hz and below) had a mild stimulating effect as indicated by increased heart rate, it seemed plausible that these subthreshold blended tones might suppress lower frequencies in the EEG. If these masked tones do suppress EEG theta then these preparations might be clinically useful for treatment of conditions found to be associated with anomalous high amplitude theta. Such conditions would include Attention Deficit (Hyperactivity) Disorder (ADD/ADHD; Lubar, 1991) and closed head injury (Hoffman, Stockdale, Hicks, & Schwaninger, 1995).

### Study One

Preliminary pilot work indicated that slower frequency tones (10 Hz and below) suppressed EEG theta (4-7 Hz). The following study was designed to determine if slow frequency tones suppressed EEG theta to a reliably greater extent as compared to a control pink noise sound with an embedded 300-Hz tone. The 300-Hz tone is the carrier frequency for the combined tones used to produce the slow beat frequencies.

The subject population consisted of thirty female college student volunteers. Each subject was tested individually in an acoustically isolated room. A unipolar placement montage at Cz (international 10-20 system) with reference and ground on the ear lobes was used. Impedance was below 5K ohms.

The experimental design consisted of three groups of 10 subjects each. On a random basis, subjects were assigned to one of the three groups and testing sequence was likewise randomized. After the electrodes were placed, subjects were instructed to sit quietly with eyes open. The visual field included the computerized equipment and the experimenter but the video monitor was turned so that the subject could not see the screen. The subject wore headsets and lis-

tened to 10 minutes of pink noise at 56 dB(C). The first five minutes consisted of pink noise with an embedded 300-Hz tone. The second five minutes comprised the experimental manipulation of the independent variable. For condition one, the second five minutes of sound consisted of pink noise with an embedded 300-Hz tone and a 310-Hz tone. For condition two, the second five minutes consisted of pink noise and an embedded 300-Hz tone and a 305-Hz tone. For the third (Control) condition the second five minutes consisted of a continuation of the pink noise with an embedded 300-Hz tone. In all cases, the tones were embedded at -25 dB(C) relative to the pink noise which is the effective range for females (Swingle, 1992).

The results indicated quite clearly that the slow beat frequencies suppressed EEG theta relative to control. The 10-Hz beat frequency (SUB/ALPHA) suppressed EEG theta by an average of 13.1% relative to baseline with 9 of the 10 subjects manifesting the suppression ($z = 3.91$, p .01, 2t). The 5-Hz beat frequency suppressed EEG theta by an average of 6.6% with 8 of the 10 subjects showing the suppression ($z = 2.86$, p .05, 2t). The 300-Hz control condition showed an enhancement of EEG theta relative to baseline (M=2.0%) with 6 of the 10 subjects manifesting the enhancement (p .30, 2t).

### Study Two

The results of study one and the pilot data indicated that SUB/ALPHA was effective in suppressing EEG theta relative to a control sound. Study two was the first clinical trial to determine if EEG theta of adult patients presenting with a diagnosis of ADD could be suppressed with SUB/ALPHA. The population consisted of four females and two males from 23 to 50 years of age. All six of the patients had been diagnosed elsewhere, and presented with the diagnosis of ADD. The assessment of the suppressive effect of SUB/ALPHA was completed during the standard psychophysiological evaluation completed at intake. The electrode montage was identical to that described in study one. Each patient was exposed to four minutes of no sound followed by two minutes of SUB/ALPHA. The average suppression of EEG theta was 24.6% (SD=14.78); t=4.08, p .01, 2t; Swingle, 1993, March). A subsequent study of 1 1 patients with various diagnoses indicated that pink noise alone suppresses EEG theta (M=14.6%), but considerably less than SUB/ALPHA (M=24.4%; Swingle, in press).

### Study Three

An important potential application of SUB/ALPHA is with children with ADD. If SUB/ALPHA does immediately suppress EEG theta with resultant enhancement of attention then it could offer an alternative to Central Nervous System Stimulants (CNSS) to maintain attention during the initial phases of neurotherapy. The population for this study were children referred for neurotherapy for ADD/ADHD. In all cases, the parents were adamantly opposed to CNSS. Two of these children were taking methylphenidate and were on their assigned dosages at the time of the assessment. Both, incidently, are now not taking methylphenidate. It is also interesting to note that the children on methylphenidate had the lowest EEG theta suppression after exposure to SUB/ALPHA.

The population consisted of nine children, four females and five males, who had been diagnosed elsewhere as ADD. The age range was from six to sixteen years. The assessment format and montage were identical to the above studies. The average EEG theta suppression was 15.5% (SD=11.6, t=4.00, p .01, 2t).

One child, an eight-year-old male, was assessed on five successive visits to determine the stability of the EEG theta suppression of SUB/ALPHA. The average EEG theta suppression was 21.4% with little variation (SD=2.56, t=18.8, p .001).

All of the children in the above group used SUB/ALPHA at home and some at school as well. The details of the use of

SUB/ALPHA are described in detail in a later section of this article together with clinical case details.

### Study Four

The sequela of mild closed head injury is often associated with anomalous high amplitude EEG theta activity. Given that SUB/ALPHA appears to reliably suppress theta activity in patients, adults and children, with ADD and to suppress theta in a nonclinical population of female subjects, it seemed reasonable to determine if patients with traumatic brain injury would exhibit such theta suppression. The population consisted of four female patients and one male patient who presented with problems associated with closed head injury. These complaints included motor rigidity, affective lability, forgetfulness, and, in all cases, problems with maintaining attention. The female patients ranged in age from 13 to 49 and the male was 19. As with the above clinical studies, the assessment of the suppressive effect of SUB/ALPHA was completed during the standard psychophysiological assessment completed at intake. The montage and presentation format were identical to that described in study two. The average suppression of EEG theta was 30.0% (SD=18.5; t=3.63, p .05, 2t).

In three of the above cases it seemed appropriate to offer the patients the opportunity to use SUB/ALPHA at home and school in the same manner as this protocol is used for patients with the diagnosis of ADD. No systematic data were obtained on the use of SUB/ALPHA for these three patients. However, in one case the patient's mother called the next week to report that she observed an immediate enhancement of positive affect and marked reduction in forgetfulness of her child. A second patient reported that with SUB/ALPHA she was able to read in a sustained manner (i.e., for more than a few minutes) for the first time since her accident six years prior to treatment. It should be noted, again, that SUB/ALPHA is not a stand alone treatment. In all of the above cases the patient was receiving some form of neurotherapy in addition to home use of SUB/ALPHA, although the latter two self-reports did appear to be primarily the result of SUB/ALPHA.

### Discussion

The results of the above studies indicate that sinusoidal subthreshold tones has a simulating effect on the autonomic nervous system as indicated by elevated heart rate and ratings of subjective anxiety. These same slow frequency harmonics suppress EEG theta activity in the majority of nonclinical subjects. Frequencies from 2 Hz to 10 Hz were found to increase autonomic arousal as measured by elevated heart rate. Harmonic frequencies of 5 Hz and 10 Hz were found to suppress EEG theta (other slow frequencies were not tested). Comparisons with control sounds of pink noise and pink noise with a subthreshold 300-Hz tone indicated that the 5- and 10-Hz harmonic subthreshold blends suppressed EEG theta to a considerably greater extent than did the control sounds. The 10-Hz blend (SUB/ALPHA) was found to suppress EEG theta approximately double the suppression of the 5-Hz blend. Other researchers have likewise determined that SUB/ALPHA suppresses EEG theta to a greater extent than a pink noise control (e.g., Budzynski, 1996). Budzynski has also shown that SUB/ALPHA appears to increase EEG 14-Hz amplitude and to accelerate EEG alpha to 10 Hz (Budzynski, 1995). The increase in EEG 14 Hz suggests that SUB/ALPHA may be useful as complimentary treatment for migraine and other pain conditions. A chronic pain patient in the author's clinic did show EEG theta suppression (10.2% with 30 second exposure) and has reported modest relief with home application of SUB/ALPHA.

In clinical populations of patients with conditions associated with elevated EEG theta, as measured in the region of Cz, these slow frequency harmonic blends of subthreshold tones suppressed EEG theta in all patients tested. As discussed in the previous

section, SUB/ALPHA may be useful for other conditions associated with elevated EEG theta or conditions that respond to treatments focused on accelerating EEG alpha or enhancing EEG 14-Hz amplitude. One such case is a patient with "paranoid attacks and nonepileptic (pseudoseizure) episodes." This patient exhibited high amplitude EEG theta and responded favorably to neurotherapy focused on reducing the EEG theta/SMR ratio (Swingle, 1994, May). This patient responded to SUB/ALPHA with a 16.7% suppression of EEG theta at Cz (t=3.69, df=8, p .01).

As a cautionary note, although the 5-Hz harmonic blend was found to suppress EEG theta (to a significantly lesser extent than SUB/ALPHA), clinical use of the 5-Hz preparation is discouraged. This recommendation is based on clinical reports from patients who used the 5-Hz preparation. Patients reported marked exacerbation of negative affective states (depression) and several complained of headache subsequent to 5 Hz use. Given the clear superiority of SUB/ALPHA, no systematic research has been focused on the 5-Hz preparation.

## Clinical Protocol For The Complimentary Use Of SUB/ALPHA

SUB/ALPHA consists of a blend of two sinusoidal tones, one at 300 Hz and the second at 310 Hz. These tones are embedded in pink noise at -17 dB(C) and at -25 dB(C) relative to the embedding medium. The details of this preparation may be found in Swingle (1992). Commercially available copies of SUB/ALPHA may be obtained from the publisher of Swingle (1992), whose address and phone number are contained in the author's notes at the end of this article.

Prior to prescribing SUB/ALPHA for complimentary home use, it is advisable to determine if EEG theta suppression does, in fact, occur with brief exposures of the sound. Given that pretreatment intake evaluations usually include some sort of EEG evaluation, the effects of brief exposure of SUB/ALPHA can be determined. Some therapists whose treatment metaphor does not include neurotherapy have used SUB/ALPHA without EEG assessment and determined efficacy in terms of other assessments such as behavioral measures, teacher/parent ratings, self-report, and the like.

### Protocol for children

ADD is the most common condition for which SUB/ALPHA is prescribed. The most important treatment consideration is that the SUB/ALPHA treatment not be under the exclusive control of the parents or teachers. In such cases one often finds that SUB/ALPHA is administered when the parent/teacher finds the child's behavior unacceptable so the child associates the treatment with a disciplinary rather than a therapeutic action.

For home use, SUB/ALPHA is presented to the child via headsets or open air (if there are no other people in the acoustic environment) continuously when they are doing homework or a scheduled reading activity. In all cases of SUB/ALPHA use, the volume must be very low so that the child is not distracted and can easily hold a conversation. When the child does not have homework, a reading activity of 20 to 30 minutes during which SUB/ALPHA is presented should be scheduled daily.

In addition to the scheduled homework or reading presentations, SUB/ALPHA should be presented for brief periods of 2 to 4 minutes several times during the time at home. Such occasions may include prior to activities such as sports, television viewing, or mealtime. Mealtime is a good example of a situation which may be viewed as a punitive application of SUB/ALPHA. Many ADHD children have difficulty remaining seated during family meals. If a parent becomes irate and orders the child to apply SUB/ALPHA, the therapeutic benefit is likely to be compromised. Incidently, placing a stool under the child's feet at the dinner table often helps the child to remain seated.

The only time that SUB/ALPHA is

applied more commonly by the parent is at waking in the morning. Many ADD children are difficult to rouse and we have found that SUB/ALPHA presented softly in the background is often beneficial in enhancing alertness.

The SUB/ALPHA tape cassette is given to the child with instructions on use. The child is also counseled on discrimination learning procedures. The child is instructed to attend to how it feels to be focused and that SUB/ALPHA will help to create that state so that the child can eventually focus attention without aids. I like to use the phrase suggested by Steve Stockdale (personal communication) that the child learn to "GET BIG" (Get Brain In Gear).

Use of SUB/ALPHA in school settings is often very beneficial. In some circumstances, the child may be prepared to use SUB/ALPHA in class. A letter is sent to the teacher explaining the use of SUB/ALPHA and inviting the teacher to call the therapist for further information. SUB/ALPHA is presented via earbud phones for brief durations during school time. The sound is kept low enough so the child can easily listen to lectures, respond to questions, and hold a conversation. The major deterrent to this procedure, in my experience, is not the teachers but rather the reticence of the child to be seen as different and needing help. Special education schools and classes are usually less problematic in this respect. Should the child refuse to use SUB/ALPHA in the classroom context, SUB/ALPHA may be used in out-of-class situations such as between class breaks, lunch, or specially arranged brief departures from the classroom.

School reports of a 7-year-old male reflect the benefit of SUB/ALPHA: Speaking and Listening—"...needs (SUB/ALPHA) to stay focused"; Independent Studies—"best with (SUB/ALPHA)"; Social Development—"much more willing to wear head phones which help considerably", "...interacts well (with other children) if using (SUB/ALPHA)"; Science—" ...good work overall, with help of (SUB/ALPHA)." These reports, and those of parents, indicate that during the early phases of neurotherapy, the child experiences an immediate benefit from SUB/ALPHA. As neurotherapy progresses, and the child learns more focused cognitive states, both in the office and with home use of the SUB/ALPHA protocol, reliance on SUB/ALPHA is reduced to very infrequent use. The above child, for example, no longer uses SUB/ALPHA in school and his home use is on an as needed basis which is about three times per week at this time.

### Protocol for adults

As noted earlier in this article, sub - threshold tones have different windows of effectiveness for males and females (Swingle, 1992). Males are more influenced by SPL in the range of -15dB(C) whereas females respond more to SPL in the range of -25 dB(C). With children this distinction is less clear and in practice I recommend that the -25 dB(C) SPL side be used for both male and female children. I do, however, tell the child that sometimes one side of the tape is preferred over the other and if they wish to experiment they should try both sides.

For adults, particularly males, the superiority of the specific window is quite apparent. Male patients often report unique physiological reactions to the -17 dB(C) preparation such as effects they noted with methylpenidate use, reactions that they do not experience or experience less intensely with exposure to the -25 dB(C) SUB/ALPHA.

After assessing the effectiveness of SUB/ALPHA on EEG theta suppression, the patient is instructed to use SUB/ALPHA upon awakening, and for brief exposures of about 2 minutes, 10 or more times during the day. They are also instructed to use SUB/ALPHA for a scheduled period of reading for 30 minutes. Further, they are instructed to listen to SUB/ALPHA while counting backwards, by 7's, from some random number in the range of 700 until they reach zero. The latter exercise should be done at some time other than the reading exercise. In addition, they are told to use

SUB/ALPHA at any other time they choose (except when driving) such as when watching TV, doing housework, and the like. Many adult patients also use SUB/ALPHA in their work environment. Brief exposures of about 2 minutes can have an effect that last for 40 minutes or so with adults (Budzynski, 1995).

## Conclusions

SUB/ALPHA is not a stand alone treatment protocol for any of the conditions described above. There have been a few cases in which university students have complained of difficulty in maintaining focus and have claimed benefit from use of SUB/ALPHA while studying. However, SUB/ALPHA has been found to be a very useful complementary treatment to neu - rotherapy. In the author's experience, home use of SUB/ALPHA facilitates the neurotherapy process. Further, this protocol permits neurotherapy to proceed at a reduced frequency of one session per week with excellent results. The total treatment length, in terms of number of sessions, also appears to be substantially reduced. Many children achieve satisfactory results in 10 to 15 sessions. A major benefit of SUB/ALPHA is that children usually have immediate positive results from SUB/ALPHA use. They report immediate gains in ability to focus on reading, sports activities, and attending during classroom instruction. Proper use of SUB/ALPHA constitutes a discrimination learning paradigm in which the child has a procedure to help to induce a state that he or she is attempting to achieve without aids. Experience indicates that this home treatment protocol markedly facilitates that learning.

It is of particular interest to note that some patients with traumatic brain injury benefit from use of SUB/ALPHA in that, much like with ADD, attention and information retrieval appear to be facilitated. At present there are too few cases to make any definitive statement other than, as described in study four above, SUB/ALPHA does suppress EEG theta in some patients with mild closed head injury.

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Although the research reported above indicates that SUB/ALPHA reliably suppresses EEG theta,the therapeutic application of this protocol should be considered experimental given the limited size of the clinical populations tested to date. Copies of SUB/ALPHA for professional use may be obtained from Professional Resource Press, 2033 Wood Street, Suite 215, Sarasota, Florida 34237-7927. (1-800-443-3364).